LEMHI RIVER HABITAT
IMPROVEMENT STUDY

Final Report

by

Dennis E. Dorratcaque, P.E.

Project Coordinator

Funded by

Larry Everson, Project Manager

U.S. Department of Energy

Bonneville Power Administration

Division of Fish and Wildlife

Contract No. DE-AC79-84BP17447

Project No. 84-28

February 1986

ACKNOWLEDGEMENTS

LEMHI RIVER HABITAT IMPROVEMENT STUDY

FEBRUARY 1986

Ott Water Engineers, Inc. (OTT) gratefully acknowledges the contributions of the following individuals: Mr. Larry B. Everson, BPA Project Manager; Mr. Dennis E. Dorratcague, Ott Water Engineers, Inc. Project Manager; and Ms. Paula M. Arsenault, Ott Water Engineers, Inc. Project Engineer. Dr. James W. Buell of Buell & Associates, Inc., Dr. T.C. Bjornn, and Mr. Kim de Rubertis also contributed significantly to the project.

We would also like to thank the Idaho Department of Fish and Game representatives: Mr. Terry Holubetz, Mr. Herb Pollard, Mr. Mel Reingold, Mr. Kent Ball, and Mr. Dale Robertson; Soil Conservation Service representatives: Mr. Ralph Swift and Mr. Neil Wilton; Shoshone-Bannock Tribes representative Dr. Rick Konopacky; U.S. Forest Service, Salmon National Forest representative Mr. Bruce May; Lemhi Irrigation District Board Members: Mr. Frank Logan, Mr. Kent Smith, and Mr. Jack Powers; Lemhi Irrigation District Attorney Mr. Jim Herndon; Watermaster for the Town Ditch Company Mr. Bob Thomas; Salmon Recorder Herald Editor in Chief Mr. Robert Johnson; and the entire technical team at Ott Water Engineers, Inc. and Buell & Associates, Inc.

TABLE OF CONTENTS

TABLE OF CONTENTS(continued)

TABLES

FIGURES

CHAPTER 1

EXECUTIVE SUMMARY

This report was prepared tor the Bonneville Power Administration (BPA) for the Lemhi River Habitat Improvement Project. The BPA's efforts on this Project are in response to the Northwest Power Planning Council's Columbia River Basin Fish and Wildlife Program (1984). The object of this Study is to determine the feasibility of enhancinq the stocks of salmon and steelhead which have declined siqnificantly over the last 80 years in the Lemhi River.

The mainstem of the Lemhi River is approximately 60 miles long with 16 major tributaries. It flows along the west flank of the Continental Divide in Eastcentral Idaho to the Salmon River at the City of Salmon, Idaho (Fiqure 1.1). Little is known of the historic runs of salmon and steelhead in the Lemhi. Runs were lost at the turn of the century, with the construction of hydroelectric facilities near the mouth of the River. With removal of the hydroelectric plant in the 1920s, salmon and steelhead have returned, but to levels below the capacity of the system to support them.

The major difficulty facing Lemhi River anadromous fish is a lack of water during upstream and downstream migrations. Most or all of the water in some reaches is diverted from the River for flood irrigation. Guidance of juvenile salmon and steelhead into irrigation works where substantial migration delays occur is also a problem. The critical period for water diversion impacts is typically from April through May when the irrigation season begins and before spring snowmelt. During this period adult and juvenile migrations of chinook and steelhead are at or near their peaks.

The specific objective of this Study was to develop methods for improving anadromous fish passage in the Lemhi River. OTT

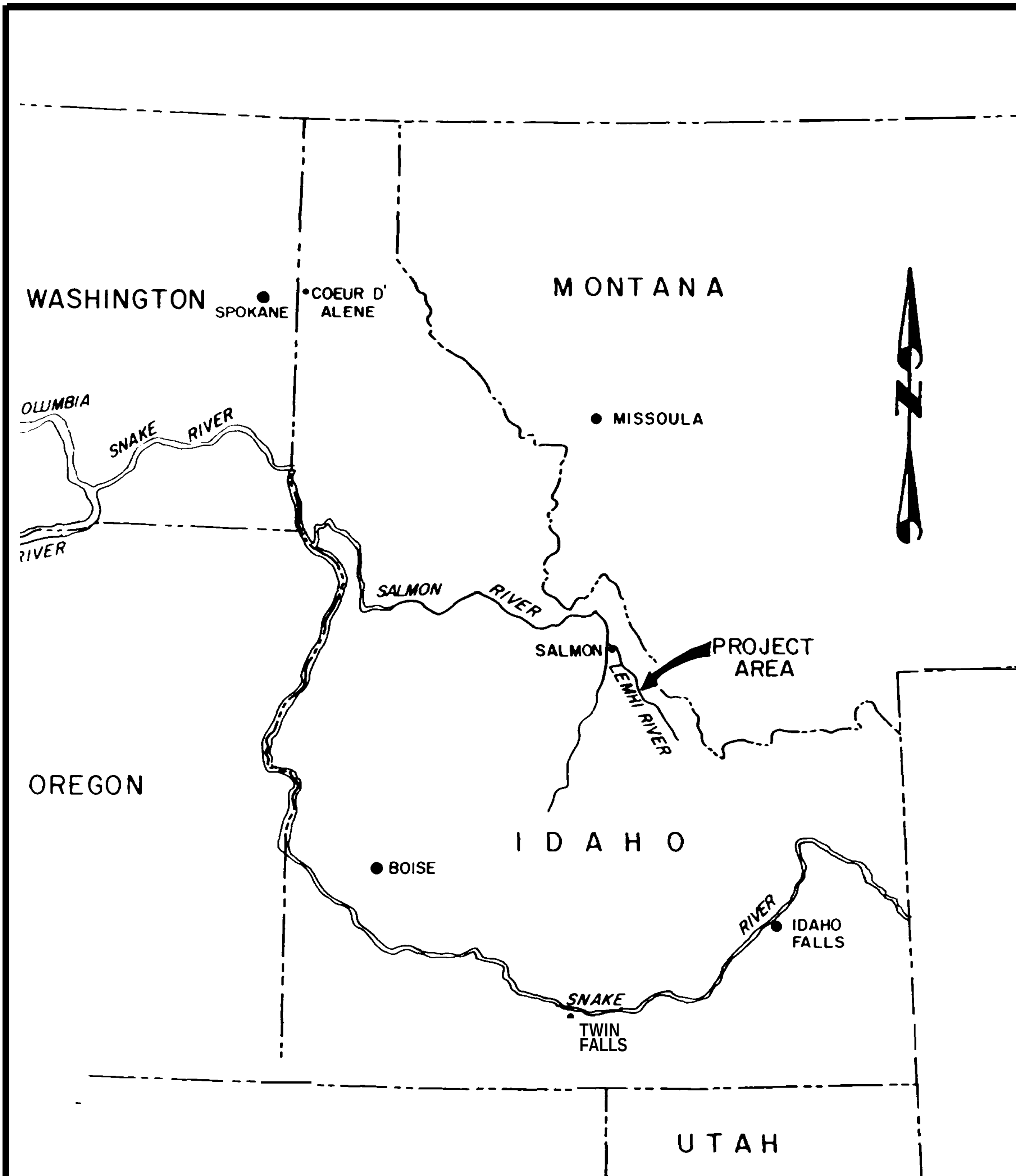


FIGURE 1.1

LEMHI RIVER
HABITAT IMPROVEMENT STUDY

LOCATION MAP

DATE: NOVEMBER 1985

JOB NUMBER: S 1028.03

OTT

accompl ished this objective through a three-phased approach. Phase I included defining the problem, conduct inq a literature search, and performing a hydrologic analysis and stream survey. Phase II developed and analyzed enhancement alternatives. Once the fishery benefits of selected enhancement options were determined, Phase III, a benefit/cost analysis, was conducted.

HYDROLOGY

The hydroloqy of the Lemhi River Basin is characterized by a complex interaction between surface water runoff, irriqation diversion practices, and qroundwater recharge. Major contributions to the stream flow are snowpack, rainfall, and return flows from flood irrigation. Hydrologic analyses focused primarily on the frequency and magnitude of low flows. OTT selected a low-flow duration of 15 days for computing the frequency of periods during which natural stream flow does not satisfy minimum fish passaqe reauirements at critical reaches. Transect measurements helped to determine minimum instream flows for passage under existing and channelized streambed conditions. OTT then determined flow augmentation quantities (the difference between actual stream flows and fish passaqe requirements) for selected reaches and combinations of options. OTT then used the results in the preliminary design ot structures, such as permanent diversion dams and levees, and to compute the economic benefits of the enhancement options.

ENHANCEMENT ALTERNATIVES

Phase II developed nine enhancement alternatives:

- Flow Concentration
- Fish Screen Improvement
- Groundwater Auqmentation

- Groundwater Irriqation
- Water Withdrawal Reduction
- Return Flow Improvement
- Sprinkler Irrigation
- Storage
- Trap and Haul

Descriptions of the nine alternatives and the results of the analyses are presented below.

FLOW CONCENTRATION

Flow concentration involves constructing permanent concrete diversion dams at several critical locations to replace temporary dams now constructed by irrigators with dozers from streambed materials. A fishway is provided at each site to provide upstream passage around the diversion. Channelization downstream of each diversion structure would be provided to concentrate flow and allow for passage during low-flow periods.

Channelization would be performed at other locations where the River channel is wide and passage difficulties are created by insufficient water depths. Since diversion dams raise flood levels, levee construction is included for flood protection.

FISH SCREEN IMPROVEMENTS

Fish screen improvement entails making recommendations for modification or repair of existing screen and bypass facilities. The objective of this alternative is to reduce delay and mortality of downstream migrants. Testing should be conducted in order to develop a suitable fish bypass system for installation at each major diversion. To ensure that improved bypasses operate efficiently, water rights should be sought for additional bypass flows.

GROUNDWATER AUGMENTATION

Groundwater augmentat ion involves pumping groundwater directly into the Lemhi River at critical fish passage points durinq low-flow periods. Using observed specific capacities obtained from the United States Geological Survey (USGS), 30 wells would be required to meet a 20-cfs minimum flow at River Mile (RM) 7.2.

GROUNDWATER IRRIGATION

An alternative to diverting surface water for irrigation is to pump groundwater. Lemhi Valley irriqators would sell partial or complete water riqhts to BPA and install more efficient irrigation systems. The remaining water rights would be transferred from surface to groundwater withdrawal. Such an exchange would only be considered for lower Lemhi Basin water riqhts, downstream of RM 8.6, where fish passaqe problems are most critical. There are several potential problems with this alternative including interference of numerous wells on qroundwater recharge, uncertain capacity of the aquifer, and the loss of priority of water riqht when chaging from surface to groundwater rights.

WATER WITHDRAWAL REDUCTION

Surface water withdrawals can be reduced by improving the efficiency of flood irriqation methods over those currently practiced. Similar to the previous alternative, irrigators would sell partial water riqhts to BPA and use the income to improve flood irriqation efficiency. This would involve leveling fields, lining canals, and laying out fields to efficiently apply irrigation water. The beneficial use of purchased water rights would be changed from irrigation to fish passage.

RETURN FLOW IMPROVEMENT

Another method to increase the overall efficiency of flood irrigation is to improve return flow. Enhanced surface and subsurface field drainage would decrease the delay associated with deep percolation and groundwater intiltration into the River. Considered possibilites include draining marshes and other natural collection areas, constructing collection ditches and ponds to drain intensely irrigated areas, or installing subsurface drains to return excess flows to the Lemhi River through pipes or ditches.

SPRINKLER IRRIGATION

Sprinkler irrigation involves the purchase of partial water rights. The irrigator could use the income from this sale to install efficient sprinkler irrigation systems. Implementation of this alternative is concentrated on the lower Lemhi River reaches where fish passage is most critical.

STORAGE

Several previous studies have focused on reservoir storage in the Lemhi Valley. OTT selected a storage reservoir site on Hayden Creek, immediately downstream from the confluence of Bear Valley Creek. The dam would be a 250-foot high roller-compacted concrete structure with a storage volume of 17,200 acre-feet. This dam was studied with and without the addition of hydroelectric power.

TRAP AND HAUL

OTT developed a trap and haul system to a conceptual level to evaluate the feasibility of transporting adult and juvenile fish around critical passage reaches of the stream. The system would consist of two facilities. A juvenile trap would be located at the site of the abandoned fish counting station, immediately upstream of Hayden Creek. This facility would guide juveniles by means of a louver barrier to a trap. Juveniles would then be transported to the Salmon River for release. An adult trap would be located near the mouth of the Lemhi, and fish would be transported to the upper watershed. Both facilities would be temporary and used only during low-flow seasons.

SELECTION OF OPTIONS

OTT presented the nine enhancement alternatives to the cooperating agencies at a meeting in September 1985. Participants decided the remaining efforts should concentrate on four options for enhancement. These options are a combination of several of the alternatives described above. The four options are:

- OPTION A:
  Permanent Diversions, Channelization, and Levees at
  L[1]-5, L-6, L-7
  Channelization only at: SPS[2]-1, SPS-2, SPS-3

---

[1] "L" signifies irrigation diversions on the Lemhi River as numbered in the "Proposed Finding of Water Rights in the Lemhi River Basin".

[2] "SPS" signifies Supplemental Passage Stations which are areas other than diversions where fish passage is difficult or blocked durinq low-flow periods.

- OPTION B:
  Same as Option A, with River Flow Augmentation through:
  - Flood Irrigation Improvement
    - 5 cfs conserved between L-7 and L-6
    - 12.4 cfs conserved between L-6 and mouth
  - Sprinkler Irrigation
    - 8.4 cfs conserved between L-7 and L-6
    - 20.7 cfs conserved between L-6 and mouth

- OPTION C:
  Permanent Diversions, Channelization, and Levees at:
  - L-5, L-6, L-7, L-20, L-22, L-31A, L-40, L-41, L-43, L-44, L-45D, L-61

  Channelization only at:
  - L-3, SPS-1, SPS-2, SPS-3, SPS-4

- OPTION D:
  Same as Option C, with River Flow Augmentation through:
  - Flood Irrigation Improvement
    - 5 cfs conserved between L-7 and L-6
    - 12.4 cfs conserved between L-6 and mouth
  - Sprinkler Irrigation
    - 8.4 cfs conserved between L-7 and L-6
    - 20.7 cfs conserved between L-6 and mouth

For each of the enhancement options, four fisheries management alternatives were considered to allow the assessment of benefits over a range of potential management scenarios. The four management alternatives are:

- Alternative No. 1
  Allow chinook salmon runs to increase naturally from prevailing levels without harvest until full seeding of juvenile rearing habitat is achieved. Screened irrigation diversion remain in their present condition.

- Alternative No. 2
  Chinook salmon are harvested at a rate that maintains a stable escapement at prevailing population levels (i.e., 330 fish). Full seedinq of juvenile habitat is not achieved. Screened irrigation diversions remain in their present condition.

- Alternative No. 3
  This management alternative is identical to Alternative No. 1 except that there is a 75 percent basin-wide improvement in downstream migrant passage conditions at screened irrigation diversions.

- Alternative No. 4
  IDFG provides full hatchery supplementation with juvenile chinook salmon to fully seed available rearing habitat during the first return cycle only. No harvest occurs until the first chinook return cycle is completed. There is a 75 percent basin-wide improvement in downstream migrant passage conditions at screened irriqation diversions.

For all four manaqement alternatives it is assumed that IDFG continues to release an average of 2,000 surplus hatchery steelhead spawners in the Lemhi River annually.

BENEFITS AND COSTS

Benefits of the four options and four manaqement alternatives were assumed to accrue from an increased number of harvestable chinook salmon and steelhead from the Lemhi River. Under existinq conditions in the River, harvestable fish are lost due to critical low-flow conditions in approximately two in nine years. If Options A or C are implemented, the recurrence interval of critical low-flows would be increased to one out of seven years.

Implementinq Options B or D would increase this to one out of thirteen years. The benefit is assumed to be the difference between harvestable fish lost under existing conditions and harvestable fish lost with a particular option.

Cost estimates for the four options, including capital and annual costs, are presented in Table 1.1. Also included in Table 1.1 are the present worth of benefits and benefit/cost (B/C) ratios for the four options for each of the manaqement alternatives.

These results indicate Option B in conjunction with Fisheries Manaqement Alternative No. 4 produces the greatest B/C ratio. Under this combination of actions, stream flows would be augmented, fish screens and bypasses improved, and supplemental stocking of juvenile chinook implemented to immediately build the Lemhi River salmon run to capacity. Thus, greater numbers of fish will be produced sooner than with the other alternatives leading ultimately to substantial harvest benefits. Except for Manaqement Alternative No. 2, Option B consistently results in the greatest B/C ratios for a given management alternative, thus demonstrating the importance of flow augmentation as an enhancement action that produces significant benefits.

Analyses of project benefits derived from Management Alternatives Nos. 3 and 4 are particularly important. They show the beneficial effect that improved downstream passaqe conditions at irrigation screening facilities in the Lemhi River will have on the run of anadromous fish. By assuminq a 75 percent reduction in the losses and delays at irrigation diversions, some of the projected project benefits become substantial, particularly Options B and D where the fish are manaqed for the maximum natural run.

IDFG has recently indicated it may manage the Lemhi River fish runs as hatchery-supplemented runs on a continuing basis, rather than on the short-term basis assumed in Management Alternative

TABLE 1.1

SUMMARY OF COSTS, BENEFITS, AND B/C RATIOS

FISHERIES MANAGEMENT ALTERNATIVE	OPTION	CAPITAL COST ($)	PRESENT WORTH OF ANNUAL COST ($)	PRESENT WORTH OF BENEFITS ($)	B/C
1	A	1,386,000	290,700	33,400	0.020
	B	1,734,000	290,700	14,900	0.007
	C	4,219,000	1,104,000	33,400	0.006
	D	4,567,000	1,104,000	14,900	0.003
2	A	1,386,000	290,700	42,800	0.026
	B	1,734,000	290,700	32,600	0.016
	C	4,219,000	1,104,000	42,800	0.008
	D	4,567,000	1,104,000	32,600	0.006
	A	1,386,000	290,700	94,800	0.056
	B	1,734,000	290,700	235,100	0.116
	C	4,219,000	1,104,000	94,800	0.018
	D	4,567,000	1,104,000	235,100	0.041
	A	1,386,000	290,700	209,800	0.125
	B	1,734,000	290,700	648,800	0.320
	C	4,219,000	1,104,000	209,800	0.039
	D	4,567,000	1,104,000	648,800	0.114

No. 4. Specifically, the rearing juvenile population of chinook salmon would be supplemented to full seeding with hatchery fingerlinqs or fry whenever adult escapement is below that necessary for full natural seeding. In addition, 550,000 chinook smolts would be outplanted to the upper watershed each year to imprint and move out. The adult fishery would be targeted on hatchery fish, not naturally-reproduced fish. Such a management program would have significant implications for the enhancement options evaluated by OTT. The commitment to seed with hatchery fry or fingerlings and the outplanting of 550,000 smolts per year would eliminate the necessity for correction of upstream migration impairment. The only benefit to the Lemhi River salmon and steelhead stocks of the options would be increased rearing habitat provided by Options B and D. These benefits would be marginal in the face of the proposed smolt outplanting program. Thus, if IDFG implements the full-scale hatchery supplementation program as described, then the options evaluated by OTT should be considered alternatives to the supplementation proqram, not an adjunct to it.

It is important to recognize that the costs associated with all options and management alternatives are greater than the expected benefits. Thus, B/C ratios are all less than 1.0.

OTHER CONSIDERATIONS

The success of any program to realize water savinqs by improved surface irrigation or sprinklers depends on cooperation from the irrigators. Whether an irriqator decides to sell all or part of a water riqht depends on the cost and crop yields produced by the improvements.

Before initiating a program to improve surface irrigation or install sprinkler systems, it is advisable to perform an assessment of actual achieved crop yields and effects on groundwater recharge. A demonstration project is one method for determining these factors. Tn addition, such a project would provide verifiable evidence to local irrigators that improved irrigation water application can produce larger and higher-quality yields.

Consideration also should be given to directly purchasing land having senior water rights. Enough land would need to be purchased to satisfy minimum flow requirements for fish at the most critical passage reaches downstream of diversions L-5 and L-6. The surface water right attached to this land could be transferred from the beneficial use of irrigation to fish enhancement. Other benefits from this alternative could be the conversion of grazing land to wildlife habitat or to public recreational areas.

BPA, as a Federal agency, cannot directly purchase land or improve irrigation systems to the benefit of an individual. The only exception is Federal "interest" in the land under consideration. It is most likely that both the holder of water rights secured in an exchange, and the purchaser of land or water rights would be the IDFG.

RECOMMENDATIONS

Based on the results of this Study, OTT recommends that enhancement Option B in conjunction with Fisheries Management Alternative No. 4 be evaluated in greater detail. This recommended Option/Management Alternative results in the greatest B/C ratio of the measures evaluated as part of the Study. Further analysis of this option should focus on the considerations previously noted regarding landowner cooperation, actual crop yields, land acquisition constraints, legal limitations, IDFG's actual fisheries management practices, and implementation of the irripation diversion screen and bypass improvement program. Completion of the screen improvement program, coupled with the testing of appropriate bypass system designs, is recommeded prior to implementation of Option B.

OTT also recommends that the complex issues of a mixed stock fishery and hatchery versus natural production be carefully examined, perhaps in an expanded fisheries production model of the Lemhi River, after the IDFG has solidified its anadromous fisheries management strategy for the River. The results of this Study will assist in that effort.

CHAPTER 2

INTRODUCTION

The Lemhi River, located in Eastcentral Idaho, is situated between the Continental Divide to the east, and the Lemhi Range to the west. From its headwaters near Leadore, Idaho, the River flows some 60 miles in approximately a northwest direction to its confluence with the Salmon River at Salmon, Idaho.

Around the turn of the century, the Lemhi was dammed near the mouth to provide hydropower. The dam was not constructed with fish passage facilities and the runs of chinook salmon and steelhead were lost. After removal of the dam in the 1920s, the chinook and steelhead runs were re-established, and by the mid-1960s there were an estimated 2,000 to 3,000 spring chinook in the Lemhi. Irrigation withdrawals and low flows have since contributed to a significant decline in the anadromous fish runs in the Lemhi.

STATEMENT OF PROBLEM

Major uses of water from the Lemhi River include irrigation, domestic water supply, and fish production. Irrigation withdrawals for grazing land and hay crops occur throughout the mainstem and its tributaries. Fish uses include rearing and spawning for steelhead, spring chinook, and resident fish. During the spring before snowmelt and the summer after snowmelt, flow in the River is often insufficient to meet irrigation needs and instream flow requirements for upstream and downstream migration of anadromous fish. Since adjudicated water rights for the Lemhi River do not provide for minimum instream flows for fish, the stream is often over drafted and impassable to fish in the lower reach of the River between Hayden Creek and the Salmon River.

Adult steelhead return to the Lemhi River during the period March 21 to May 30 with most of the migration occurring during the period April 10 to May 20 (Bjornn, 1978). Juvenile out-migration occurs in September through January and again in April through June. Adult spring chinook salmon migration in the Lemhi River begins as early as mid-May and continues throughout the summer until approximately mid-September. Peaks in upstream migration generally occur in mid-June and late August. Downstream migration of spring chinook juveniles occurs throughout the year. True seaward miqration, however, occurs in the months January to June with peak migration in April (Bjornn, 1978).

The irrigation season in the Lemhi Basin runs from approximately April 1 to November 1 of most years (seasonal variation in weather may change this timing). Migration of anadromous fish occurs principally within the irrigation season, especially during the low-flow period of April and May. During low- to average-water years, a conflict usually exists between irrigation and fish uses. The conflict is due primarily to limited flow in the lower River and irrigation dams at various locations on the River.

OBJECTIVE OF THE STUDY

The need for improved migration, spawning, and rearing flows in the Lemhi River was addressed in the Northwest Power Planning Council's Columbia River Basin Fish and Wildlife Program (1984). The Council directed the Bonneville Power Administration (BPA) to fund the Lemhi River Habitat Improvement Program under Section 700 of the Fish and Wildlife Program. On August 17, 1984 the BPA retained Ott Water Engineers, Inc. to perform this Study under Contract No. DE-AC79-84BP17447.

The Study was performed in three phases:

- Phase I - Literature Search, Problem Description, Hydrology, and Stream Survey.

- Phase II - Analysis of Alternatives for Habitat Enhancement.

- Phase III - Detailed Stream Survey, Estimate of Smolt Production, and Benefit/Cost Analysis.

The objective of Phase I was to identify the problem and revise the scope of work contained in the contract, if necessary, to facilitate a cost-effective and thorough analysis that meets the requirements of the cognizant agencies. Additional efforts in Phase I, Literature Search and Hydrology, provided the background information necessary for Phase II. Phase II was a development and analysis of enhancement alternatives. The objective of Phase II was to investigate enhancement alternatives to a level that determined if they are individually feasible, or some combination of alternatives is feasible. The objective of Phase III was to determine the auantity and quality of spawning and rearing habitat that would be available to anadromous fish if alternatives developed in Phase 11 were implemented. Further objectives of Phase III were to determine the smolt production capability of the Lemhi River if habitat enhancement measures are implemented, and finally to determine the benefit/cost ratio of proposed alternatives.

Phase I of the Study is reported in Chapter 3. The description and analysis of enhancement alternatives, Phase II, are presented in Chapter 4. The details of the benefit analysis, benefit/cost ratios, and results and conclusions, which comprise Phase III, are given in Chapters 5, 6, and 7.

CHAPTER 3

ANALYSIS

In the analysis portion of the Study, data and analysis results were compiled as input to Phases II and III of the Study. The collection and analysis of background information was performed in a step-wise process. Each milestone represented the completion of a Study task, tor which OTT produced a draft task report. Throughout the Study, and especially in developing preliminary designs for alternative solutions, modifications and additions were made to the approach and details of the analysis. This chapter summarizes the details of our final assessment of background literature, water rights, basin hydrology, materials and construction costs, and fish habitat availability.

LITERATURE SEARCH

During the initial stages of the Study, OTT performed a comprehensive literature search and data collection effort: subseuuently, OTT identified the types of essential information that needed to be gathered from agencies, libraries, and personal communication.

An annotated bibliography of data and information sources is presented in Appendix C. The bibliography is divided into the following major categories: Hydrology, Water Rights and legislation, Fisheries, and Geology. In addition to a description of the contents for each publication, the utility of that source is summarized.

OTT's analyses used all the sources initially collected. Although data were collected during the course of the Study, OTT developed the core background materials in the initial stages. Interviews, personal communication, and field trips provided a great amount of supporting data for the evaluation of alternative solutions.

WATER RIGHTS ISSUES

BACKGROUND

The division and appropriation of water has created conflict in the agriculturally-based Lemhi River Basin for over 50 years. Topsoils are generally gravelly or sandy and quite porous, particularly in the upper portion of the Basin. The exception is along the lower floodplain where silty loam soils are present. This combination of physical conditions is not conducive to high-value row crops, so the predominant agricultural products are alfalfa-grass hay and pasture for cattle. Water supply for irrigation and domestic use during the summer is enhanced (relative to the sparse amount of precipitation) by springs and groundwater in the Basin's hydrologic system.

ADJUDICATION

Eight petitioners (water users in the Lemhi Valley) initiated the adjudication of water rights in the Lemhi Basin by requesting the Idaho Department of Water Administration (now the Idaho Water Resources Department or IWRD) adjudicate the water resources of the Lemhi River and its tributaries. Based upon claims submitted by users, old records and files at IWRD, and field studies of the Lemhi Valley, the Department issued a proposed finding. This document tabulates the water right claimants as well as the priority, purpose, period of use, and maximum rate of each diversion. The document lists both surface water and groundwater rights.

The "Proposed Finding of Water Rights in the Lemhi River Basin" states several factual findings regarding the causes for dispute among water users and the general irrigation practices of ranchers in the Valley. These findings include:

- There are periods during the year when the appropriated water rights of irrigators exceed the available stream flow in the Lemhi River and its tributaries. Thus, the River can be diverted in its entirety at times, especially in the spring prior to snowmelt and in the latter part of the summer when crop demand is highest.

- The diversion of water from Lemhi tributaries has, at times, been without regard for the priority of rights of mainstem users, which is contrary to Idaho's "first in time" policy.

- Water right quantities are set by acreage, crop requirements, and transport losses. The allowances for water loss due to canal and ditch leakage as well as application inefficiency are generally high.

- The Lemhi Basin has basically no storage facilities. Generally, during late April or early May, irrigators apply large quantities of water to their fields to store water in the soil and to raise the water table. This practice begins in the upper Lemhi Basin a few weeks earlier than in the lower Basin.

- There are certain minimum stream flows and required return flows associated with fish screen facilities that have been established as part of the adjudication. However, the priority of these water rights is low.

- Each user must install and maintain a suitable headgate and measuring device.

In essence, the document outlines the major water use problems in the Lemhi Valley and specifies the basis on which resources were divided.

Unfortunately, there are several major discrepancies between the requirements made in the adjudication document and the actual practices by irrigators in the Valley. For instance, OTT discovered that there is no watermaster monitoring water quantities except for the Town Ditch Company. Individual users or Board members of the Lemhi Irrigation District (LID) settle disagreements. The LID is an association of water users whose main function is to arbitrate water use disputes among its members. Adjudicated quantities may not at all be related to the amount of water actually diverted, i.e., ranchers basically take what they need from the River. This practice is actually legal, because according to Idaho law, unlimited quantities can be diverted as long as there are no conflicts for usage. Based on initial observations, the high allowance for ditch and application efficiencies seems to be warranted. Most transport canals are rough, porous, and inadequately maintained, and application methods are generally not efficient. During field visits, OTT found very few headgates were adequate for correctly measuring diverted flow auantities.

The table in Appendix A, developed from the adjudication document, lists all the diversions on the mainstem Lemhi River. The significant remarks referring to "critical" and "problem" diversions are reaches where fish migration is most compromised, according to Idaho Department of Fish and Game personnel in Salmon, Idaho. Appendix B gives maps of the River that identify irrigation diversion and stream flow measurement locations.

WATER LAW

There are several facets of water law in the State of Idaho which will affect efforts to improve conditions for anadromous fish in the Lemhi River.

The following statements affect the general approach to the Study or the consideration of several alternative solutions:

- All water in natural channels, lakes, and springs is the property of the State of Idaho and is therefore subject to appropriation, including qroundwater. Any alternatives which consider replacing or supplementing surface diversions with spring or groundwater sources must account for the process of securing the appropriate water rights.

- A water right is not a property right in itself; it becomes an appurtenance of the land to which it is applied. This is the reason that the status of instream rights on the Lemhi is in question. Although the State considers fisheries to be a beneficial use, all currently-established minimum flow bypass rights at screen facilities are specified for only a point source, not for a length of river or stream. There is a possibility that instream rights could be established. However, instream flows would have to be associated with prior (old) water rights in order to be beneficial to fish on a consistent basis.

- No user can interfere with prior right diversions, i.e., the first in time is the first in right. This principal will affect any alternative which includes obtaining new instream rights or the purchase of old water rights.

- After a construction permit is issued to install a diversion or storage structure or some other installation for beneficial use, work must begin within five years. Such a law would apply to any alternatives for building permanent diversion or dam structures.

- It is the policy of Idaho water law to secure the maximum use and benefit from water resources in the State.

- In order to obtain the water quantity to which a claimant is entitled, claimants can alter the River bank or bottom without obtaining the usual permits for channel alteration. Thus, each year claimants use bulldozers, rocks, and hay bales to build temporary dams which sometimes extend the width of the River.

The following statements affect the consideration of specific alternative solutions:

- Several legalities must be weighed when assessing groundwater irrigation or the possibility of supplementing stream flow in the Lemhi with well water. The method or type of diversion (surface versus groundwater) may be changed if the rights of other claimants are satisfied. However, changing the type of right (i.e., from surface right to groundwater right) does not maintain priority. When wells interfere with each other or with surface diversions, the policy of prior rights applies: historic pumping levels must be maintained.

- Purchasing land with old surface water rights and changing the beneficial use to fisheries is one of the alternatives under study. The IWRD must be provided with information regarding the transfer or sale of a water right, and all such actions are subject to Department approval. In this case, the “new” beneficial use (fisheries) would have the same priority as the “old" beneficial use (irrigation) if both rights were of the same type (i.e., a surface water right).

- A general policy exists for using water efficiently. Even though a water right is attached to the acreage to which it is applied, a right can be obtained by simply diverting flow and applying it to beneficial use. These factors could allow water "saved" through irrigation efficiency to be applied on different or new acreage. However, this possibility is lessened by the fact that there is almost no available land in the lower Valley for expansion and that desert reclamation in the upper Basin is expensive.

- Installation of a storage reservoir in the Lemhi system is an alternative that has been studied since the 1940s by the Bureau of Reclamation and Corps of Engineers, and is subject to numerous legal requirements. If stream flow is interrupted by the storing of water in a dam, downstream water claimants have a right to "ordinary" flow if needed. Storage rights are treated separately from other types of consumptive uses, and are considered to be a different type of right.

ALLOCATION

The method by which water rights are allocated is site specific and based upon consumptive use and various losses for a particular application. In the past, a miner's inch per acre has been used for determining allowable water requirements. For 100 acres, this would amount to about 3 cfs throughout the irrigation season.

More recently, considerations have been qiven to crop requirements and transport or application losses.

In the Lemhi Valley, about 1.5 to 2.0 acre-feet per acre are reauired at the field to satisfy the consumptive use of the crops and the evaporation loss over one irriqaton season. Depending on the location of the field and the method of irrigation, losses are added for application inefficiencies, percolation, and ditch losses. On a basin-wide average, this total amounts to approximately 15-20 percent of the water right at the field. Upon determining the land area and water requirement for the point of diversion, a water volume can be calculated. Using the period of irrigation, a quantity of flow is then computed which is the maximum amount allowable for diversion.

Although this analysis is fairly detailed to evaluate the flow actually needed by a claimant, one must remember the general law of "beneficial use". This allows ranchers to divert virtually all of the sprinq runoff in the Basin for intense application to their fields in order to store water in the soil.

CONCLUSION

The water availability and allocation problems in the Lemhi River Basin are complex and not subject to simple solution. One of the factors complicating this Habitat Improvement Study is the water law relatinq to irriqation and drainage. Basically, these laws were established to favor agriculture as the most beneficial use and to settle disputes among claimants. In evaluating the alternative solutions for the Rasin, both the legalities and practical application of water rights issues were considered.

HYDROLOGY

INTRODUCTION AND OBJECTIVE

The Lemhi River Habitat Improvement Study required an evaluation of the hydrologic characteristics cf the Lemhi Valley. OTT's qoal was to assess the interaction between surface water runoff, groundwater influences, and irrigation withdrawals in order to define the frequency and quantity of low flows at certain critical reaches. In addition, OTT identified steelhead and chinook salmon minimum flow requirements for passage. The combined products from these analyses resulted in the stream flow quantities which must be provided for successful fish passage.

This section presents the results of our analysis, which provided the basis for preliminary desiqn of alternative solutions and for OTT's recommendations for improving fish passage and habitat in the Lemhi River.

APPROACH

In order to achieve these objectives, the work was divided into four subtasks as follows:

Subtask 1 : Target Minimum Flows
Compute the stream flow necessary for salmon and steelhead passage.

Subtask 2 : Existing Low Flows
Determine the quantity and f reauency of occurrence of historical low-flow periods at critical reaches.

Subtask 3 : Flow Augmentation

Calculate the quantity of flow which must be added to the River in order to satisfy fish passage requirements. Also, attach a frequency and amount of time (duration) to these stream flow values.

Subtask 4 : Groundwater Hydrology

Develop the groundwater and geologic parameters necessary for evaluating alternatives that include groundwater pumping.

REACHES AND SUBREACHES

The Lemhi River and Hayden Creek were divided into stream reaches based on major hydrologic inflow points, observable differences in channel type, and areas identified as historically critical to fish passage due to extended low-flow periods. These critical reaches have been defined through field investigations and consultation with Idaho Department of Fish and Game (IDFG).

Eight major river reaches have been defined for the Lemhi River and its main tributary, Hayden Creek. These are shown on Fiqure 3.1. Each reach was numbered sequentially so that subreaches could be identified with a lettering system (e.g., lA, 1B, lC, etc.). Subreaches for Hayden Creek were also defined with this number-letter code system.

The eight reaches and their locations are as follows:

1. Lemhi River - Mouth (RM 0.0) to Baker (PM 12.0, at L-11*).

---

* Refers to surface water diversion. See Appendix B.

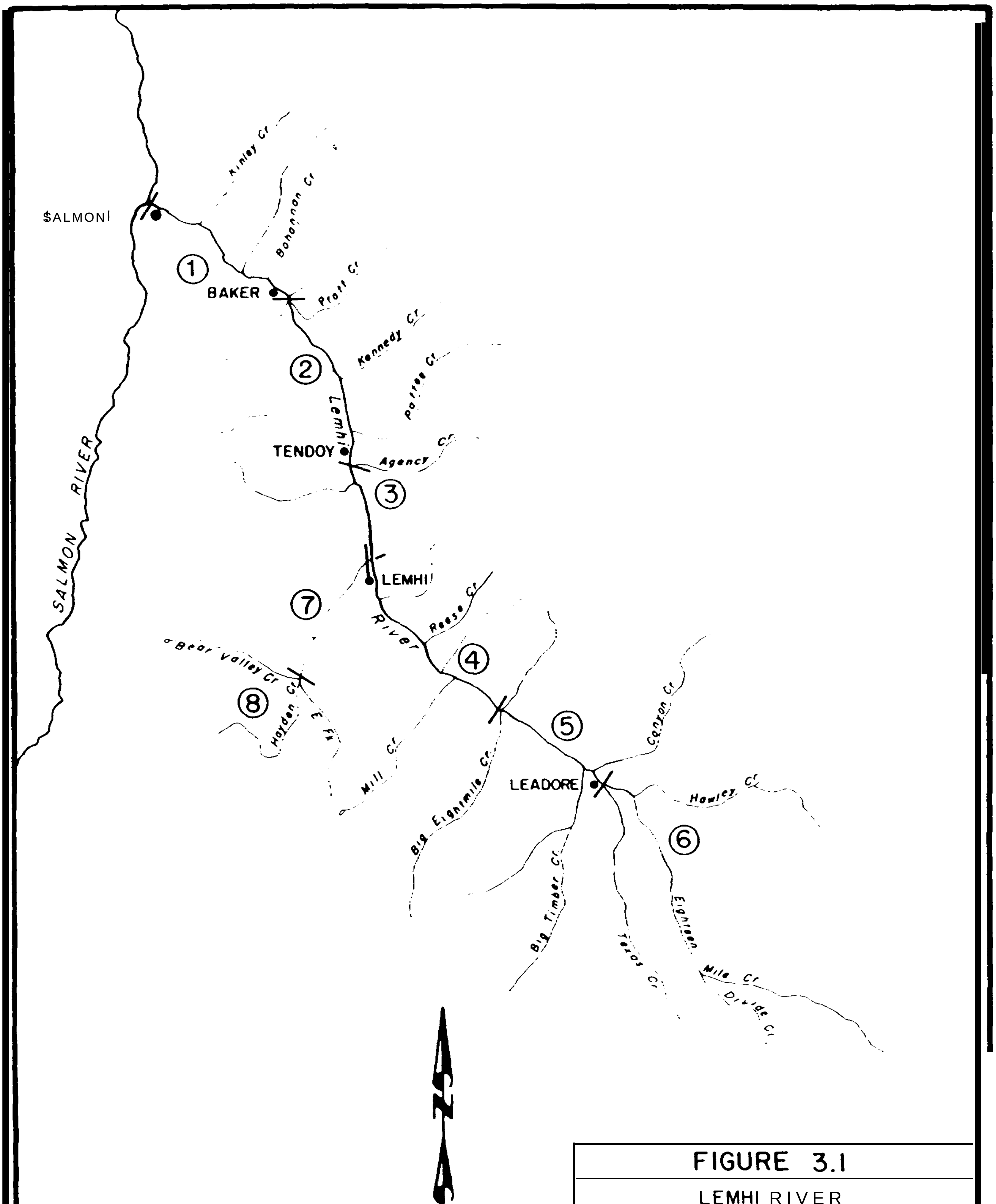


FIGURE 3.1

LEMHI RIVER
HABITAT IMPROVEMENT STUDY

REACH DEFINITION

DATE: NOVEMBER 1985

JOB NUMBER: SI028.03

OTT

2. Lemhi River - Baker (RM 12.0, at L-11) to Agency Creek Confluence (RM 22.8, at L-30).

3. Lemhi River - Agency Creek Confluence (RM 22.8, at L-30) to Hayden Creek Confluence (RM 30.3, at L-41).

4. Lemhi River - Hayden Creek Confluence (RM 30.3, at L-41) to Big Eightmile Creek Confluence (RM 45.1, at L-58A).

5. Lemhi River - Big Eightmile Creek Confluence (RM 45.1, at L-58A) to Confluence of Eighteenmile Creek and Texas Creek (RM 52.3, at L-63).

6. Lemhi River - Headwater Streams (above RM 52.5).

7. Hayden Creek - Mouth (CM 0.0) to East Fork Confluence (CM 9.1).

8. Hayden Creek - Headwater Tributaries (above CM 9.1).

DIVERSION AND MEASUREMENT LOCATIONS

OTT mapped and tabulated the location and flow auantities for all diversions along the mainstem Lemhi River. These data provided a basis for analyzing the hydrology of the Basin because of the importance of flow diverted for irrigation. During spring and summer of 1985, OTT made three trips (May, June, and July) to the Lemhi Valley to measure flows in the River and collect information. OTT also gathered records of flow measurements taken by the Lemhi Irrigation District (LID) for several irrigation seasons.

OTT and the LID flow measurement locations and diversions are listed in the table in Appendix A. OTT locations are prefixed by "LOC" and LID measurement points are given a prefix of "LM". The irriqation diversions have the prefix "L". These identifiers will he referred to in the following sections addressing target and predicted historical minimum flows.

TARGET MINIMUM FLOWS

Objective

The purpose of this subtask was to estimate minimum flows for upstream salmon and steelhead passage in the Lemhi River system. The results were compared with historical low-flow values of various frequencies in order to determine the flow quantities which must be conserved or added to the system at critical locations.

Stream Flow Data

Flows at various points alonq the River are a function of runoff, tributary inflow, qroundwater contribution, and irrigation withdrawals. OTT staff took flow measurements at 28 consistent locations along the Lemhi River and its tributaries during each field trip. OTT also measured many other locations along the River and in irrigation ditches during the June and July trips. Staff then computed depths, velocities, and several other hydraulic parameters for the transect measurements at each location.

Minimum Flow Analysis

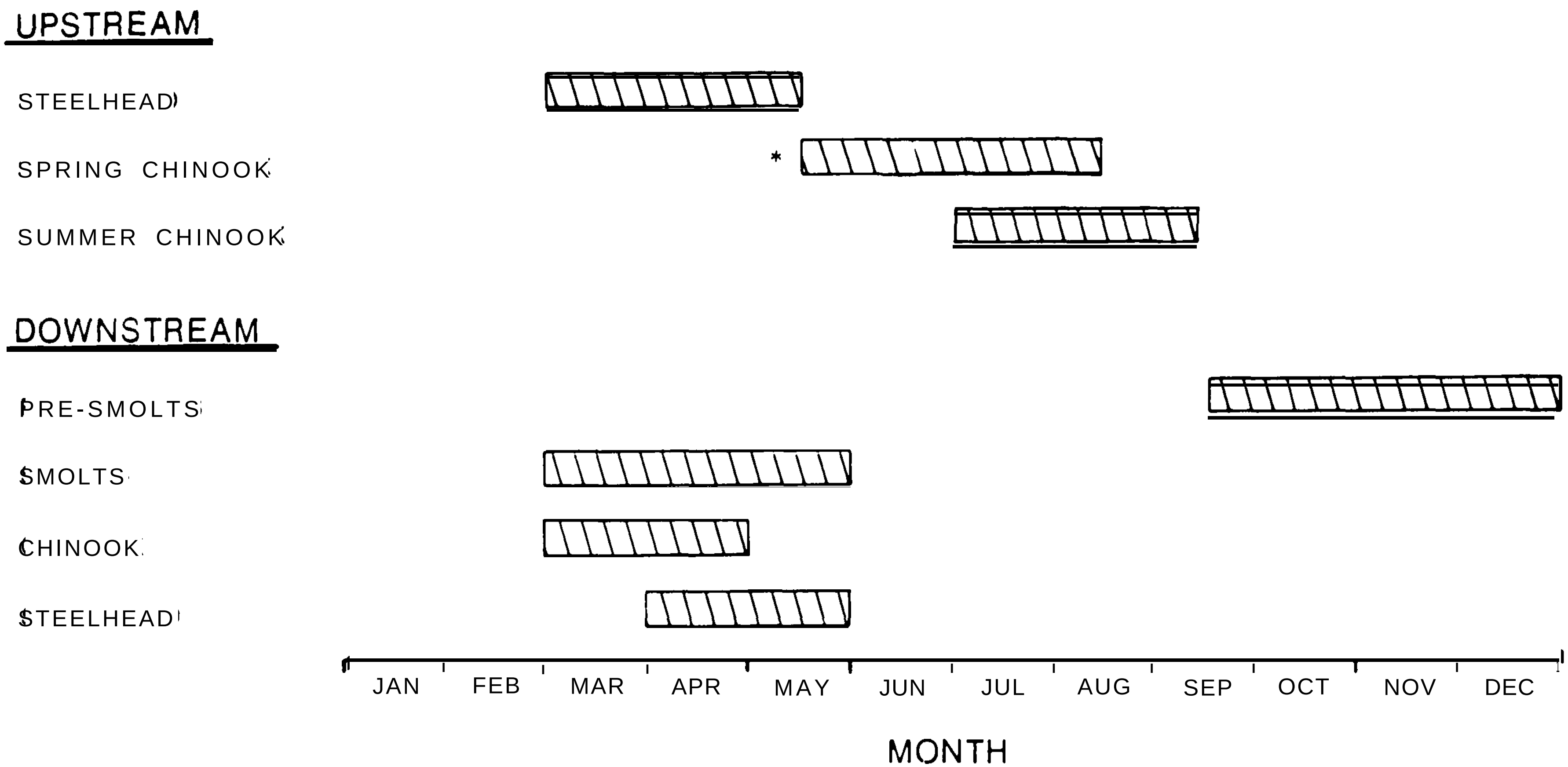
In determining instream flow quantities for salmon and steelhead, OTT collected information on fish passage requirements. Additionally, OTT reviewed literature pertaining to studies conducted on the Lemhi River Rasin. Using selected criteria, the results of our hydrologic studies and cross-section surveys, OTT performed a hydraulic analysis to compute minimum flow for various reaches of the River. Instream flows recommended by OTT's Study are based on transect measurements within five of the Lemhi River Basin reaches. The Study also determined a minimum flow for Hayden Creek near its confluence with the Lemhi.

A relatively limited amount of information is available on passage reuuirements for adult anadromous fish and smolts. Most instream flow studies are oriented toward spawning habitat, such as those conducted on the Lemhi River by Cochnauer (1977) and on Big Sprinqs and Big Timber Creeks by Horton (1982, 1984). Because of the importance of adult passage problems on the Lemhi, created by low-flow periods combined with irrigation diversions, OTT developed a depth-flow function.

Fish Migration

Anadromous fish in the Lemhi River Basin must maintain their flow requirements for upstream and downstream passage, spawning, incubation, rearing, and for maintenance of water quality (Goodnight and Bjornn, 1971). The discussion below is directed towards the problem of upstream passage because of the consequences which can occur, such as decreased run size, when a generation of adults is prevented from spawning.

Migration timing in the Lemhi River varies considerably from year to year. This probably results from variations in temperature and turbidity downstream from the Lemhi in the Salmon River, and flows within the Lemhi Basin. Figure 3.2 shows average timing of adult steelhead and chinook salmon based on data from the Lemhi weir trap taken between 1965 and 1975 (Bjornn, 1978). During some years, salmon returns peak as early as mid-June, while delayed runs in other years may peak in mid-July with a secondary peak in early September. It is therefore important that instream flow be carefully monitored to coincide with fish periodicity each year,



* INDICATES POSSIBLE EXTENT OF MIGRATION PERIOD

FIGURE 3.2

LEMHI RIVER
HABITAT IMPROVEMENT STUDY

STEELHEAD & CHINOOK MIGRATION PERIODICITY

DATE: NOVEMBER 1985
JOB NUMBER: S1028.03

OTT

or that minimum flows be maintained throughout the potential migration season.

Passage Criteria

Instream flow criteria for passage mainly involve water depth, although the Study considered water velocity, channel width, length of critical passage area, and other factors. Thompson (1974) and the Oregon Department of Fish and Wildlife (Oregon Method) proposed depth criteria in natural streams for salmon and steelhead as 0.8 feet for chinook and 0.6 feet for adult steelhead. These depths assume that passage is across a shallow bar of limited length. In these studies, passage criteria had to be met over a continuous section of channel representing at least 10 percent of the stream width. No criteria were given for length of the passaqe blockage.

Based on OTT's measurement of stream flows at 28 transect locations within the five River reaches, it appears that velocities are not a limitinq factor for passaqe during low flows. Limiting areas appear to be short blockages near irrigation diversions or lonqer riffle areas where the fish may have to sustain swimming for distances of several hundred feet in shallow riffles.

Passage criteria that were utilized:

1. For passaqe blockages less than 20 feet in length:

    a. Averaae channel depth must exceed 0.8 feet, or

    b. Maximum channel depth should be at least 1.0 feet over a continuous section of 10 percent of the stream width.

2. For blockages over 20 feet in lenqth, requiring sustained swimming:

   a. Averaqe channel depth should be at least 1.0 feet, or

   b. Maximum channel depth should exceed 1.25 feet over at least a continuous section of 10 percent of the stream width.

OTT evaluated each measured cross section seoarately so the proper set of criteria, 1 or 2, could be applied. Subsequently, minimum flows were computed using the method described below.

Flow Computation

Using the depth criteria and transect measurements taken during May, June, and July of 1985, OTT computed hydraulic parameters so that Manning's equation could be used to develop minimum flows.

Transect surveys were plotted and flows were computed for each measurement taken on the Lemhi River and Hayden Creek. From these plots, certain variables from Manning's equation could be computed for field-observed flows, such as Q, R (or A/WP), and A. Inserting an estimated value for channel roughness, n, the energy slope for measured flows could be calculated by using Manninq's equation:

$$Q = \frac{1.49}{n} AR^{2/3} S^{1/2}$$

where:

Q = flow (cfs)
n = roughness coefficient
A = area (ft^2)
S = slope (ft/ft)
R = hydraulic radius (ft)

Channel depth, stream width, and blockage length criteria were applied to the measurement locations along the Lemhi River using the transect plots. The criteria depths resulted in new values for A, wetted perimeter (WP) and R. These hydraulic parameters, combined with the previously calculated energy slopes and the estimated roughness coefficients, allowed the computation of minimum flows at each measurement location.

Minimum Flow for Channelization

In addition to estimating minimum flows for the existing River channel, OTT applied passage depth criteria to the artificial channel cross section, described in the Flow Concentration Section of Chapter 4. Channelization is intended to concentrate low flows in the thalweg (main flow channel) in order to enhance migration. Using a typical river slope and roughness, the resulting minimum channel flow is 6 cfs in the excavated channels.

Results

Based on the approach of combining depth criteria with a hydraulic analysis, OTT developed minimum flow recommendations. These flows are summarized in Table 3.1. Each minimum flow is identified with a measurement location code (Appendix A), river mile, criteria selection, and reach number.

EXISTING LOW FLOWS

Objectives and Approach

The objective of performing a hydrologic analysis of the Lemhi River was to reconstruct flows at "critical" reaches, with particular emphasis on the low-flow regime. Low-flow guantities and the frequency with which these occur are important because of the impacts on chinook salmon and steelhead migration.

TABLE 3.1

MINIMUM REQUIRED FLOWS FOR UPSTREAM PASSAGE
LEMHI RIVER

LOC #*	RIVER MILE (MI)	MINIMUM FLOW (CFS)	LOCATION REMARKS
1	1.20	28.1	between L-l and L-2
2	4.70	25.3	between L-3A and L-3B
8	7.07	19.0	downstream of L-5
7**	7.14	20.3	immediately downstream of L-5
4**	7.33	14.5	immediately downstream of L-6
5	7.42	11.9	immediately upstream of L-6
9	9.20	29.0	between L-8 and L-8A
10	13.10	35.2	at L-14
11	16.65	35.0	between L-19A and L-20
13	18.30	39.3	between L-23 and L-24
14	22.70	39.9	just downstream of L-30
15	25.00	26.1	at USGS gage
16	25.60	31.9	just downstream of L-31A
17	28.50	23.9	between L-38 and L-39
18	29.90	22.1	between L-39 and L-40
20	30.80	25.0	upstream of L-42A & B
21	33.50	24.9	downstream of L-49
22	37.10	25.8	upstream of L-45D
23	39.50	37.1	at L-48
19	H-0.50	16.4	Hayden Creek near confluence with Lemhi

* These are OTT measurement location codes. See maps in Appendix B.

** Most critical locations for passage during low flows.

The task included three steps:

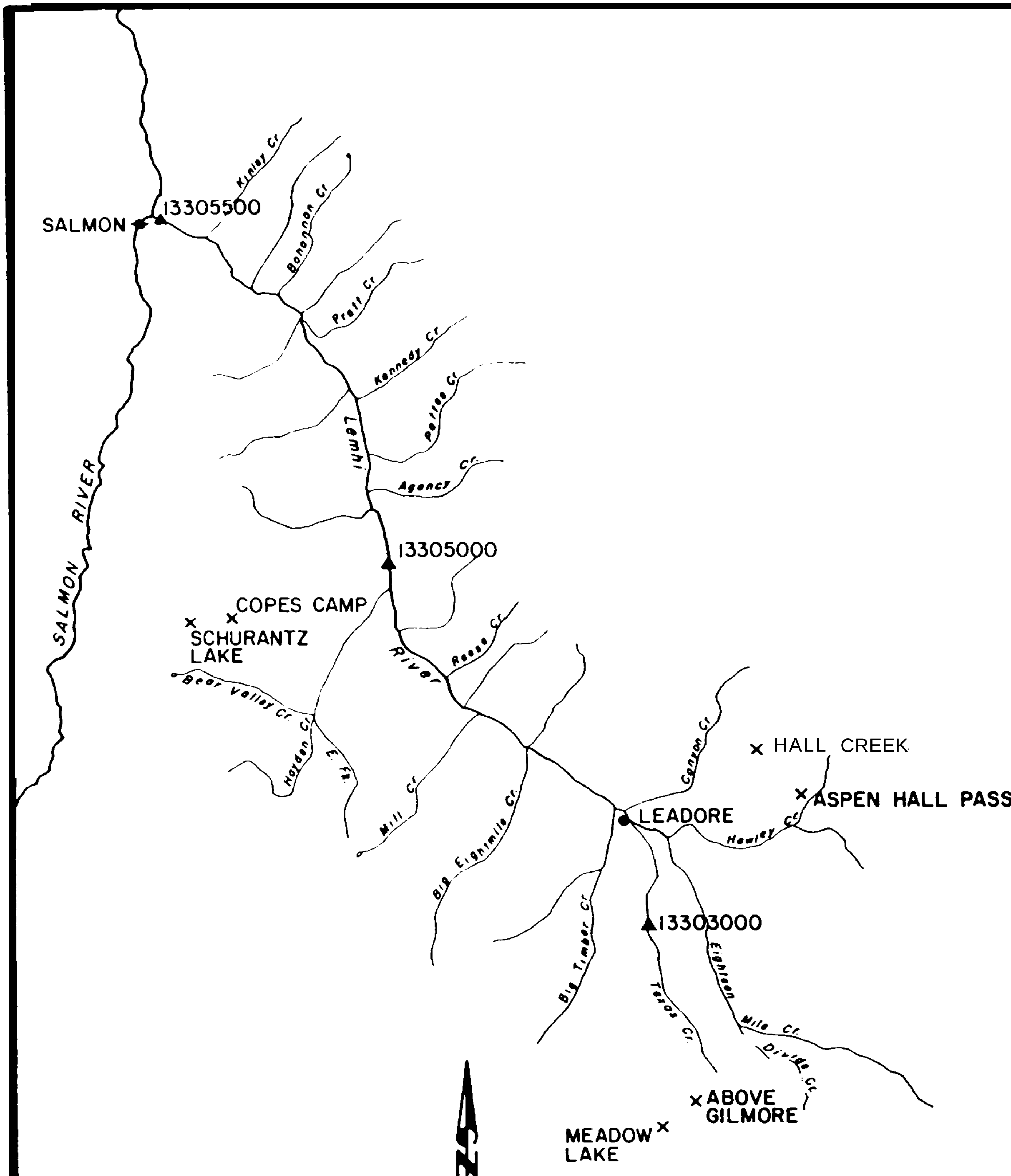
- o Acquisition and evaluation of basic hydrometeorologic data.
- o Data analysis, including estimation of irrigation and groundwater return flow along the Lemhi River.
- o Reconstruction of flows and derivation of flow duration and flow frequency curves for critical reaches between Leadore and the confluence with the Salmon River.

Data Acquisition

Stream Flow Data

The U.S. Geological Survey (USGS) has collected stream flow data at a number of sites in the Lemhi Basin. LID and OTT also have made numerous miscellaneous measurements of both mainstem flows and irrigation withdrawals. Maps in Appendix B delineate OTT and LID measurement locations. Table D.l in Appendix D gives the station names, drainaqe area, and periods of record for the available USGS data. The locations of the principal gaging stations are shown on Figure 3.3.

On Table D.l the only USGS qaqe now in operation is gage 13305000 (Lemhi River near Lemhi). This gage provides the record OTT utilized in correlating qaged flow with miscellaneous measurements taken by LID and OTT to develop a flow model. The record starts in 1938, with gaps from 1939 to 1955 and from 1963 to 1967. Data collected prior to 1967 were taken at a site 1.4 miles upstream of the current gage location. There are three large irrigation diversions between the old and new gaging stations: therefore, only data collected at the present gaging site since 1967 were of value for use in this Study.



K E Y

▲ STREAM FLOW GAGE

● PRECIPITATION GAGE

◆ PRECIPITATION AND TEMPERATURE GAGE

X SNOW SURVEY SITE

FIGURE 3.3

LEMHI RIVER
HABITAT IMPROVEMENT STUDY

LONG-TERM DATA COLLECTION SITES

DAT E: NOVEMBER 1985

JO8 NUMBER: SI028.03

OTT

Precipitation and Temperature Data

The National Weather Service has collected daily precipitation data at both Salmon and Leadore and daily maximum and minimum temperatures at Salmon. Station characteristics and periods of record are given in Table D.2 and the station locations are shown on Figure 3.3. Boxplots of monthly precipitation at Salmon are given in Figure D.l.

Snowpack Data

The Soil Conservation Service operates several snow survey sites in the higher elevations of the Lemhi Basin from which snowpack water equivalent may be obtained for the first day of every month from January through April. Table D.3 shows the station elevation and period of record. Figure 3.3 shows the survey sites.

Data Analysis and Results

Reconstruction of low flows in the Lemhi River was based on the analysis of daily stream flow data at the USGS gage near Lemhi from 1968-1984 (a total of 17 water years). Approximate relationships were developed to correlate low flows at the gage with those at critical diversion points. These relationships were established by comparing miscellaneous discharge measurements at various locations on the River with concurrent data for the gage using a mass balance analysis.

The mean quartiles (25 percent, 50 percent, and 75 percent exceedances) of the monthly flows at the Lemhi gage for the period of water years 1968 through 1984 are given in Table D.4, and plotted in Figure D.2. Flow duration curves based on daily data were also calculated for the Lemhi gage for the months of March through September and are shown in Figures D.3 through D.9.

Annual 15-day low flows were then calculated from daily flow data for two flow seasons, "spring" and "summer". These data were ranked and plotted on probability paper. Fitted log-normal probability distributions were developed and graphed. Curves for the gage are presented in Fiqures D.10 and D.ll in Appendic D, and for Hayden Creek on Figures D.12 and D-13.

Flow Seasons

Two flow seasons were defined for the irrigation period. This was necessary to differentiate between normal groundwater return flows, and hiqher return during the summer flows due to excessive flood irrigation. Timing and intensity of the irrigation season fluctuates from year to year, depending on climatic conditions and available stream flow. Therefore, the occurrence of peak flow due to snowmelt was selected to divide the spring and summer seasons. The spring season extends from mid-March to the peak of River flow due to snowmelt, while the summer season extends from peak flow through mid-October. Mid-March and mid-October are the limits on the period of irrigation in the Lemhi Valley.

The shape of the curves in Figures D.10 and D.11 shows that the probability and intensity of low-flow events vary considerably between the spring and summer seasons. Spring stream flows are most variable because the snowmelt runoff, snowpack quantity and quality, temperature, rainfall, and irrigation diversion withdrawals all can interact in combinations of timing and magnitude. This is the reason why critical low-flow events occur relatively frequently in the lower Lemhi Valley.

Low-Flow Duration

A duration of 15 days was established as the critical low-flow duration. This represents the approximate amount of time required to produce a blockage to salmon and steelhead migration from the mouth of the Lemhi to the headwaters, where habitat is most abundant (Buell, pers. comm.). OTT developed frequency curves for 7-day and 15-day low flows. These curves were very similar.

Groundwater Return

Intense flood irrigation contributes significantly to the groundwater return flows during the mid to late irrigation season; therefore, groundwater returns are generally lower and more consistent in the spring season. It was determined that different groundwater return flow rates occurred at four reaches.

Once irrigation water percolates and moves through the aquifer, return flows increase during the summer season. Then they become hiqhly dependent on the soil and rock characteristics of the aquifer along the floodplain of the Basin. Thus, six reaches exhibiting uniaue groundwater return characteristics were identified for summer flow analyses. Boundaries of flow reaches were set at LID or OTT measurement locations to coincide with the mass balance analysis.

Hayden Creek Analysis

In order to predict stream flow upstream of Hayden Creek, the major tributary to the Lemhi River, an analysis was made of contributing flow. Bureau of Reclamation records as well as OTT and LID measurements of Hayden Creek flow were used to correlate daily data at the USGS gage at Lemhi to the data taken at Hayden Creek. Ratios were developed relating average monthly flows on Hayden Creek at the mouth to those at the Lemhi River gage. These ratios are presented in Table D.5 (Appendix D). A synthesized daily flow record for Hayden Creek was then created and used in assessing 15-day low flows (Fiqures D.12 and D.13).

East/West Channel "Split"

Several critical areas have been identified in the East Channel upstream of the point where the River "splits" (between L-58B and L-58C). Therefore, an estimate was developed for the average division of flow between the East and West Channels. Field data collected by OTT and Buell & Associates, Inc., show approximately 55 percent of total Lemhi River flow upstream of the "split" is in the East Channel.

Lemhi River Flow Model

Groundwater return flows were estimated to develop a model for further estimating 15-day low flows upstream and downstream of the USGS gage. Total return flow represents the sum of groundwater returns via the Basin aquifer (deep percolation) plus surface returns from irrigation waste. These estimates were made using Lemhi River and diversion canal measurements taken by OTT during 1985 and LID during 1979, 1981, and 1983. Measurements of Hayden Creek are included also in these data.

In addition, the average utilization (percent) of adjudicated water right was quantified. Because of the tremendous influence that irrigation withdrawals have on Lemhi River flow, this factor is important to the estimation of both return and stream flows.

A mass balance approach was taken in applying data gathered by OTT and LID to estimate return flow. The general equation follows:

Q2 = Q1 - (DIVERSIONS * WRU) + (RETURN RATE * (RM1 - RM2))

where: Q2 = a measured or predicted flow downstream of Q1, (cfs)

DIVERSIONS = the sum of diverted flow between Ql, and Q2 sites (cfs)

WRU = average fraction of water rights utilized (%used/lOO%)

RETURN RATE = groundwater and surface return flow rate (cfs/mile)

RMl = river mile of 01 site (mi)

RM2 = river mile of Q2 site (mi)

Values obtained for return flow rate were assessed to determine seasonal average values. Diversion canal measurements also were analyzed for developing water right utilization percentages for spring and summer. Subsequently, these results were integrated into a model for computing seasonal 15-day low flows at each diversion. Return flow and WRU values are presented in Table 3.2 for specified reaches. These parameters were used in all alternative solution designs.

Predicted 15-day low flows, immediately below each irrigation diversion for return periods of 2, 10, 20, and 50 years, are shown in Tables D.6 (spring) and D.7 (summer). Mean seasonal 15-day low flows, which were used in assessing fisheries benefits, are given in Tables D.8 and D.9. These were created by applying shifts to low-flow values developed for the USGS gage.

Flood Frequency Analysis

Instantaneous high flows were obtained from the USGS for each year of record at the gage near Lemhi. These flows were ranked and plotted on log probability paper. Upon fitting a curve to the data, the 50-year design flood for the River at the USGS gage was estimated at 2,050 cfs.

TABLE 3.2

RETURN FLOWS AND WATER RIGHT UTILIZATION

SPRING SEASON

Water Right Utilization = 85%

Reach	River Mile	Return Flow (cfs/mile)
Mouth to LM3	0.0 to 8.9	8.0
LM3 to USGS Gage	8.9 to 25.0	7.0
Gage to "split"*	25.0 to 45.9	4.0
Upstream of "split" (channels)	45.9 to 52.3	4.0

SUMMER SEASON

Water Right Utilization = 100%

Reach	River Mile	Return Flow (cfs/mile)
Mouth to LM3	0.0 to 8.9	11.5
LM3 to USGS Gage	8.9 to 25.0	14.0
Gage to LOC21	25.0 to 33.5	6.5
LOC21 to LOC23	33.5 to 39.5	4.0
LOC23 to "split"	39.5 to 45.9	8.0
Upstream of "split" (channels)	45.9 to 52.3	6.0

* Point at which River splits into two basic channels, East Channel and West Channel, approximately seven miles north of Leadore.

FLOW AUGMENTATION

Objective and Approach

To improve fish passage and habitat in the Lemhi River, stream flow during dry or critical periods could be augmented through surface water conservation, groundwater pumping, regulation, or other alternatives. The objective of the flow augmentation subtask is to determine the quantity of water that must be provided, by single or combined alternatives, in order to improve salmon and steelhead migration in the Lemhi River. The results of the flow augmentation analysis were used in the preliminary development of alternative solutions.

Analysis and Results

The stream flow augmentation quantity for a particular reach is the difference between the required flow for fish passage under present channel conditions and the historical 15-day low flow at that location. Tables 3.3 and 3.4 present flow augmentation quantities at critical locations for spring and summer, respectively. Zero values indicate minimum flows for passage have been met historically for river flows of that return period.

Several options, described in Chapters 4 and 5, include channelization of the riverbed. Return periods were identified for the minimum flow requirement in the design channel. Table 3.5 identifies quantities for spring and summer at the two most critical locations, below L-5 and L-6.

GROUNDWATER INVESTIGATION

Objective and Approach

The purpose of investigating groundwater in the Lemhi Basin was to gather information and perform a generalized analysis of soil and

TABLE 3.3

FLOW AUGMENTATION QUANTITIES

SPRING

AUGMENTATION LOCATION		MINIMUM FLOW (CFS) & LOCATION			STREAM FLOW AUGMENTATION (CFS)			
					RETURN PERIOD (YRS)			
CRITICAL REACH DESCRIPTION	RIVER MILE	DESCRIPTION	RIVER MILE	MINIMUM FLOW	2	10	20	50
Below L-5	7.14	LOC7	7.14	20.3	0	20.3	20.3	20.3
Below L-6	7.40	LOC4	7.33	14.5	0	14.5	14.5	14.5
Below L-7	8.30	LOC5	7.42	11.9	0	0	9.7	11.9
Below L-20	16.70	LOCll	16.65	35.0	0	0	0	4.85
USGS Gage	25.00	LOC15	25.00	26.1	0	0	0	0
Below L-41	30.30	LOC20	30.80	25.0	0	0	0	0

Note: Augmentation quantities assume that flow added or conserved at a specified location will not be diverted downstream.

TABLE 3.4

FLOW AUGMENTATION QUANTITIES
SUMMER

AUGMENTATION LOCATION		MINIMUM FLOW (CFS) & LOCATION			STREAM FLOW AUGMENTATION (CFS) RETURN PERIOD (YRS)			
CRITICAL REACH DESCRIPTION	RIVER MILE	DESCRIPTION	RIVER MILE	MINIMUM FLOW	5	10	20	50
Below L-5	7.14	LOC7	7.14	20.3	0	20.3	20.3	14.5
Below L-6	7.40	LOC4	7.33	14.5	0	12.1	14.5	14.5
Below L-7	8.30	LOC5	7.42	11.9	0	0	0	0
Below L-20	16.70	LOC11	16.65	35.0	0	0	0	0
USGS Gage	25.00	LOC15	25.00	26.1	0	0	0	0
Below L-41	30.30	LOC20	30.80	25.0	0	0	0	0

TABLE 3.5

FLOW AUGMENTATION QUANTITIES
FOR CHANNELIZATION

SPRING

LOCATION	RETURN PERIOD ((YRS) 2	10	20	50
Below L-5 (LOC7)	0	6.0	6.0	6.0
Below L-6 (LOC4)	0	6.0	6.0	6.0

(actual return period tor 6.0 cfs below l-5 is 4.5 years)

SUMMER

LOCATION	2	10	20	50
Below L-5 (LOC7)	0	6.0	6.0	6.0
Below L-6 (LOC4)	0	3.6	6.0	6.0

(actual return period for 6.0 cfs below L-5 is 3.3 years)

Note: A minimum flow of 6 cfs is assumed for the design channel which is described in Chapter 4.

geologic parameters. This provided a basis for evaluating alternatives that involve groundwater pumping. Soils analyses also were useful in assessing all alternatives that include irrigation, water transport, or storage.

In addition to feasibility testing, soils and geologic data were used to estimate the interaction between Basin groundwater and the Lemhi River. Based on field observations and measurements, groundwater contributes significantly to Lemhi River stream flow.

Data Sources

The Soil Conservation Service provided a soils map and interpretation records of soils in the Valley. The U.S. Geological Survey provided geologic data and reports as well as expert consultations. The geology of the lower Lemhi Basin has been mapped by A.L. Anderson (1956-1961). E.T. Ruppel has recently done intensive work on the upper Valley. In addition, valuable background information was gathered from personal conversations with local ranchers and agency personnel in the Lemhi Valley.

Analysis

Reqional Geology

The Lemhi Valley and adjacent mountain ranges lie within the norhtern Rocky Mountain physiographic province. This northwest-trending, broad, U-shaped, glacial-cut Valley is bounded by two mountain ranges, the Beaverhead to the northeast and the Lemhi to the southwest. Bedrock units in these mountain ranges are not important aquifers and are not addressed in this section. The Lemhi Valley floor is dominated by Late Tertiary and Ouaternary alluvial, colluvial, and glacial deposits. These are sequences of successive alternating sand, gravel, and clay layers. Flood plain alluvium consists of various unconsolidated, poorly-sorted, cobbles, gravels, sand, and silt.

Reqional Soils

The occurrence of soil types in the Lemhi Valley varies from the upper to the lower reaches. For the purpose of this investigation, concern is given to the soils which affect the aquifer.

Soils on the River flood plain throuqhout the Valley consist of the Fury-Levelton-Keele group. These are moderately- to poorly-drained soils on bottom lands and alluvial fans. The soil profile in the lower Valley consists mainly of the Pattee-Geertsen-Lacrol association close to the flood plain. These are generally deep, well-drained soils weathered from bedrock. The Pattee series is a silt loam with gravelly sand and is the major irrigated soil in the area. The flanks of the lower Valley contain soils of the Dawtonia-Dacore-Cronks association and are very deep, well-drained soils that formed in alluvium or colluvium from extrusive igneous rocks. The upper Basin consists almost exclusively of the Whitenob-Pahsimeroi group. These are very deep, excessively-drained soils formed in alluvium from mixed geologic materials on fan terraces. Percolation of irriqated water into these gravelly sandy loam soils is rapid.

Groundwater Occurrence

Groundwater occurs in virtually all of the geological formations in the Lemhi Basin, but varies in amount. The Quaternary Tertiary sediments are by far the most important aquifer in the Lemhi and adjacent basins. High yields occur in the upper Valley where these sediments are thick and laterally extensive. The Valley narrows near the confluence of Hayden Creek, and sediment depth becomes less, resultinq in potentially lower yields from wells and 1 ower return flows. Complex relationships between bentonitic clay layers and these sediments make the extent of confining beds undefinable without geophysical examination and aquifer tests.

Groundwater Movement and Return Flow

The U.S. Geological Survey has mapped the potentiometric surface in the Lemhi Basin, which illustrates a generalized direction of groundwater movement. Figure 3.4 was created from the USGS map. Groundwater tends to move from areas of high to low altitude.

The movement of groundwater in relation to the Lemhi River is important when discussing return flow and location of wells. The upper Valley is a broad basin with a thick sequence of sediments. The direction of water movement is directly towards the River. Valley width decreases in the lower Valley as does sediment depth. The geology and soils also become more complex, which influences groundwater movement. The direction of movement is nearly parallel to the Lemhi River in the downstream direction. There are sites where pumping is not possible unless irrigators up the Valley start operations early, supplying the aquifer with percolated irrigation water. These delicate balances in the lower Valley dictate that careful consideration should be given to well placement.

The return flow rates computed in the previous section were validated by evaluating data from the Lemhi Basin, utilizing data from similar basins, and communicating with irrigators and agency personnel.

The Pahsimeroi Rasin to the southwest is similar in climate, topography , and geoloqy. Water Information Bulletin No. 31 released by the Idaho Department of Water Administration recorded groundwater levels in selected wells in the Pahsimeroi River Basin throughout the annual cycle of 1974. When these graphs were compared with a graph of mean monthly precipitation, a rough estimate of the rate of groundwater movement could be derived. The maximum precipitation in the Pahsimeroi Basin occurs in June.

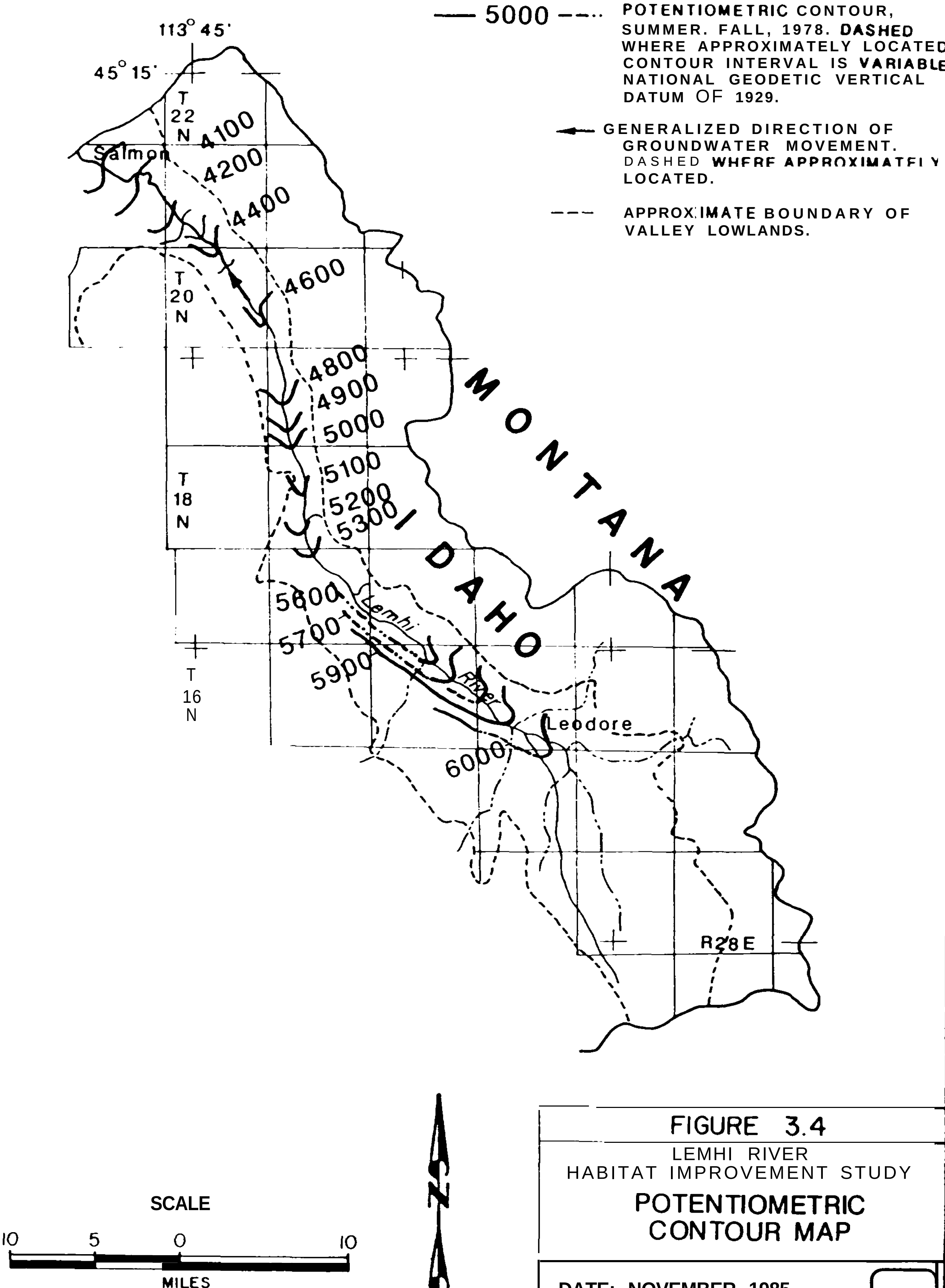


FIGURE 3.4

LEMHI RIVER
HABITAT IMPROVEMENT STUDY

POTENTIOMETRIC CONTOUR MAP

DATE: NOVEMBER 1985

JOB NUMBER: S102803

OTT

The water in wells in the upper Valley reach a maximum level in July. Maximum levels in the middle and lower Valley occur in August. This would indicate an approximate two-month return flow rate. Because of the resemblance between the Lemhi and Pahsimeroi Basins, a similar correlation can be made between runoff and groundwater recharge. This one and one-half to two-month return rate has been confirmed through conversations with irrigators and agency personnel.

Well Location

The exact location of wells required for groundwater alternatives cannot be determined without an intensive examination of geophysical characteristics and detailed aquifer tests. The type of geophysical examination and location of aquifer tests would have to be resolved through further study and field investigation. However, it is obvious that the most important aquifer in the Valley is in the Quaternary Tertiary sediments. These sediments contain alternating layers of sand, qravel, and clay along with silty shales which are locally bentonitic (Anderson, 1961). Yields from wells in this aquifer depend on compaction, character of interbeds, and sorting. Geophysical examination could define the extent of confining beds for possible well sites by determining yield and probable interference. The number of wells required by an alternative depends on well yield to meet design frequency reauirements and on drawdown. Size and type of pumps depends on the well yield and pumping head at a specific site.

Groundwater Availability and Yield

In evaluating the availability of groundwater at critical sites, Darcy's Law can be applied using generalized conditions. Since data are insufficient for a detailed aquifer analysis, assumptions are made to simplify the model:

$$Q = KIA$$

where: Q = auantity of water per unit time

K = hydraulic conductivity, which depends on the size and arrangement of water-transmitting pores

I = hydraulic qradient

A = cross-sectional area measured perpendicular to the direction of flow

By examininq drilling logs, test data from the IWRD, and field observations, a value for (K) was selected for a medium-qrained sand and estimated to be 1,000 gal/day/ft^2. The value estimated for (I) is .007 ft/ft and was determined from published potentiometric surface contours (USGS, 1979). Cross-sectional areas (A) were calculated by multiplying the Lemhi Valley width at a given site by the aquifer thickness. This is, at best, an approximate model, and the parameters are estimated.

Based on these generalized conditions, the following capacities can be expected from the aquifer in the vicinity of critical Lemhi River reaches (identified by proximity to diversions):

L6	-	0.87 cfs
L7	-	0.89 cfs
L20	-	0.97 cfs
GAGE	-	0.32 cfs
L41	-	0.58 cfs

These values also assume noninterference between adjacent wells.

There is a wide range of capacities in wells currently operating in the Valley. Reported well yields from the U.S. Geological Survey are from 1 to 300 gal/min with specific capacities ranging from l-30 (gal/min). Because of these low yields, it would take a multitude of wells and a network of pipelines to deliver the necessary supplemental flow to the critical sites.

Results

The analysis of Lemhi Basin geology and soils provided data for adjusting qroundwater inflow values, identifying likely well locations and areas of high return, and estimating well yields. These results are used in the analysis of alternative solutions.

COST COMPUTATION PARAMETERS

INTRODUCTION

The purpose of developing cost computation parameters was to establish a uniform set of unit costs used in preparing estimates for all enhancement alternatives. This would ensure that alternatives could be compared on a uniform basis.

Unit costs represent the price for specific quantities of material, completely finished. Examples are costs for a cubic yard of structural concrete or a cubic yard of rock excavation. These are intended to be realistic and representative of actual field costs. A realistic analysis of alternatives will be dependent primarily on the proper estimation of auantities and application of unit costs. Tables of unit costs for Sprinq 1985 dollars are presented in Appendix E.

The unit costs presented in Appendix F are divided into various labor and material categories. Values for labor-intensive operations or products have been determined using cost estimating guides and experience. Costs for readily available items were determined from estimates of local suppliers. For items of variable size, such as pumps, several different sizes were priced; intermediate sizes were estimated using a scale or equation.

Accuracies of unit costs vary. Values for off-the-shelf items are within 20 to 30 percent of actual cost in nearly all cases.

Labor-intensive operations or products may vary greatly in price and are expected to be within 40 percent.

FISH HABITAT ASSESSMENT

ASSESSMENT OBJECTIVES

The capacity of the Lemhi River Basin to produce spring chinook salmon and summer steelhead could be increased by improving fish passage and rearing conditions in the Lemhi River. The enhancement of stream flows would result in improved upstream passage conditions for adult fish migrating to spawning areas of the upper Lemhi, and better downstream passage conditions for outmigrant salmon and steelhead. Increased stream flows in the lower Lemhi during the low-flow period could also increase rearing habitat for juvenile fish.

In order to assess the potential benefits of enhanced stream flows associated with alternative management options (measured by adult returns and smolt production), Buell S Associates, Inc. was retained to develop the data necessary to address the following two assessment objectives:

- To quantify the relationship between salmon and steelhead rearing habitat and stream flow for the Lemhi River.
- To estimate the juvenile chinook salmon and steelhead production that would result in the Lemhi River Basin if problems with low flow were rectified.

To accomplish these objectives, Buell S Associates implemented a step-wise benefit assessment procedure that included the following elements:

- A detailed stream survey
- Determination of flow/habitat relationships
- Estimation of habitat availabiltiy at low flow
- Estimation of habitat availability with enhanced flow
- Determination of rearing densities at full seeding
- Estimation of rearing potential under present and enhanced-flow regimes
- Estimation of benefits of improved upstream passage conditions
- Estimation of increased run sizes to result from improved downstream passage conditions
- Estimation of increased run sizes to result from alternative management options

ASSESSMENT METHODOLOGY

All streams in the Lemhi River Basin likely to realize significant increases in anadromous fish production as a result of Project implementation were surveyed at known stream flows between June 23 and August 1, 1985. Streams in the Basin were divided into a total of eiaht major reaches, based upon hydrology, channel characteristics, potential for fish production, and fish passage problems (Figure 3.1). Major reach boundaries were established in consultation with fish biologists from the Idaho Department of Fish and Game (IDFG) and Dr. Ted Bjornn of the University of Idaho.

Fish habitat parameters in the major reaches encompassing the Lemhi River, Hayden Creek, and Biq Springs Creek were inventoried in an extensive stream survey. The entire length of each major reach of these streams was walked to inventory available fish rearina habitat, factors limiting juvenile fish production, obstructions to fish passage, and specific opportunities for improved fish passaqe and rearinq conditions in the Lemhi Basin. General stream characteristics examined in each major reach included:

- Channel geometry
- Shading and bank condition
- Point and non-point sediment sources
- Barriers to juveniles and adults
- Instream cover
- Overwinterinq and high flow refuge areas

Each major reach surveyed was broken into subreaches bounded by consecutive pairs of irriqation diversions. This subdivision broke the reaches into distinctive stream segments with generally similar channel characteristics but frequently dissimilar flows. Both the availability of salmonid rearing habitat and prevailing passage conditions in each of these subreaches are substantially affected by the withdrawal of water at their upstream ends (diversions).

Rearing habitat puts a qreater restriction on salmon and steelhead production in the Lemhi Basin than does spawning habitat (Bjornn, pers. comm.). Increasing stream flow in the Lemhi River will improve both spawninq and rearing conditions for these fish, but the rearing habitat will continue to limit fish production. For this reason, attention focused upon available rearing habitat in the Lemhi River and its relationship to stream flow. Spawning habitat for salmon and steelhead was studied qualitatively, ascertaining where in the Lemhi Basin these fish are most (and least) likely to spawn if their numbers increase as a result of Project implementation.

At the recommendation of Dr. Bjornn, available rearina habitat in each subreach was auantified using a modification of the method described by Irving et. al. (1983) at known stream flows. Stream length was determined for each subreach by pacing. Proceeding upstream from the lower end of a subreach, visual transects were established perpendicular to stream flow at every tenth pace. Fish habitat intersected by each transect was classified into six habitat types compatible with available fish production data on Idaho streams: (1) pool, (2) riffle, (3) run, (4) pocketwater, (5) backwater, and (6) side channel. Main habitat areas were classified as deep, slow-water areas (pools), flat shallow areas (riffles), areas of intermediate depth and high velocites (runs), and riffle areas interspersed with small pools (pocketwaters). Associated habitat types were those areas situated off the main channel and out of the current (backwater), and stream channels containing less than 25 percent of the stream flow (side channels). The wetted width of each habitat type intersected by each transect was estimated to the nearest foot, often by pacing, and recorded. The pace of each stream surveyor was periodically calibrated.

Fish habitat in the upstream ends of irrigation ditches, between diversion points and fish screens, also was quantified. Habitat in ditches below fish screens was not examined during the inventory because:

- Fish access is limited

- Juveniles which rear in ditches face a considerable risk of mortality due to stranding

- Fish production in ditches is currently minimal and is unlikely to be increased

Following field data collection, the surface areas of the six habitat types in each subreach of stream were calculated.

Stream flows recorded for each subreach are estimates developed from the flow model described in the Hydrology section of this chapter. For many subreaches the flows recorded were measured within two days of the inventory date. Flows for subreaches not measured by OTT were extrapolated from stream flows for the nearest upstream and downstream subreaches, which were determined usinq the stream flow model of the Lemhi River.

The relationship between stream flow and available fish habitat was examined in the five major river reaches likely to be affected by flow augmentation (Reaches l-5). Thirty-two sampling stations, each 100 yards in length, were established along the Lemhi River between the mouth and Leadore (Table 3.6). Stations within each major Study reach are representative of stream conditions prevailing within the reach and contain varied aggregations of habitat types. Stream flow and the surface area of each of the six habitat types identified during the detailed stream survey were measured at the 32 stations under both moderate and low-flow conditions. These habitat and stream flow measurements were used to define how stream flow affects the quantity and composition of available fish habitat in the five major Study reaches of the lemhi.

For each sampling station, surface area measurements for the habitat present at two levels of stream flow were converted to percentages of the bank-full surface area (%BF). The stream flow

TABLE 3.6

FISH HABITAT STATIONS

STATION	STUDY REACH	RIVER MILE	NEAREST WATER DIVERSION
H-l	1	0.9	below diversion L-l
H-5	1	3.9	below diversion L-3B
H-15	1	5.4	below diversion L-3A
L-5	1	7.2	immed. below diversion L-5
L-6	1	7.4	immed. below diversion L-6
H-20	1	8.2	below diversion L-7
L-7	1	8.3	immed. below diversion L-7
H-25	2	12.2	above diversion 1-12
H-30	2	14.4	above diversion 1-16
L-20	2	16.7	immed. below diversion L-20
H-35	2	16.8	above diversion L-20
H-40	2	19.7	above diversion l-26
H-54	3	24.7	above diversion L-31B
H-55	3	25.7	below diversion L-31A
L-31A	3	25.8	immed. below diversion L-31A
H-57	3	28.3	above diversion L-38A
H-60	3	30.2	above diversion L-40
L-41	3	30.3	immed. below diversion L-41
L-43	4	31.9	immed. below diversion L-43
H-65	4	32.6	above diversion L-43C
L-44	4	33.7	immed. below diversion L-44
H-70	4	36.6	above diversion L-45B
L-45F	4	36.9	immed. below diversion L-45D
H-75	4	39.2	below diversion L-47
H-77	4	41.2	below diversion L-50
H-80	4	43.8	below diversion L-53
H-82	4	45.0	below diversion l-58A
H-85	5	47.6	above diversion L-59
H-88	5	48.5	above diversion L-60
L-61	5	49.3	immed. below diversion L-61
H-90	5	52.1	below diversion L-62
L-63	5	52.3	immed. below diversion L-63

Stations with "L" prefixes were situated immediately below water diversions of ten causing fish passage problems, and "H" prefix stations were located elsewhere in the Lemhi River between the mouth and Leadore, Idaho.

and habitat data for all the stations were then pooled by major Study reach (l-5) for regression analysis. Both linear and curvilinear regressions of %BF versus stream flow were performed on the data for each specific habitat type within a major reach. The regression equation accounting for the greatest amount of the observed variation in %BF for each specific habitat type was used to describe the relationship between stream flow and %BF for that habitat type within the reach.

Regress ion equations were developed to collectively describe the relationship between stream flow and the six identified habitat types in the five Study reaches of the Lemhi River. These equations then were used to create a habitat/stream flow model. The model predicts the surface area (square yards) of each habitat type in any diversion-bounded subreach of the Lemhi River below Leadore, Idaho for any given stream flow. The primary basis for these predictions is the following algorithm:

$$S2 = (S1)(\%BF2)/(\%BF1)$$

Where:

S1 = Surface area of the specific habitat type in a subreach during the stream survey conducted by Buell & Associates, Inc.

S2 = Predicted surface area of the specific habitat type in that subreach, given the stream flow of interest (flow predicted by the stream flow model given a specific set of assumptions regarding flow recurrence frequencies, flow augmentation, and season or month of interest).

%BF1 = %BF for the specific habitat type predicted by the regression eauation for the appropriate Study reach, given stream flow in subreach at time of stream survey (flow predicted by the stream flow model).

%BF2 = %BF for the specific habitat type predicted by the regression equation for the appropriate Study reach, given the stream flow predicted for the subreach under a particular project option.

If only the algorithm above is considered, the surface area of habitat predicted for a subreach could exceed the bank-full surface area of the subreach. Therefore, the habitat/stream flow model is desiqned to limit %BF to 100 percent. This was done by reducing the projected surface areas of specific habitat types as necessary. Surface areas of specific habitat types which tend to disappear first as stream flow rises were reduced to zero first. The surface areas of habitat types which tend to persist or to increase in areas under the same conditions were reduced last. The sequence of surface area reductions built into the model, from first to last is: pool, side channel, backwater, "pocket" water, riffle, and run. The results are shown by subreach in Appendix F.

This habitat/stream flow model was used to estimate the amount and quality of rearing habitat for juvenile salmon and steelhead in the Lemhi River under current and enhanced stream flow conditions. It was assumed that an average annual 15-day summer low flow represented conditions limiting the number of smolts produced at full seeding. Available rearing area was estimated for the following two stream flow conditions:

1. Prevailing average annual 15-day summer low flow (for each of 81 subreaches of the Lemhi River, as predicted by the stream flow model).

2. Enhanced average annual 15-day summer low flows (for each of 81 subreaches of the Lemhi River, as predicted by the stream flow model) resulting from ranchers below diversion L-7 switching from flood to sprinkler irrigation (Options B and D).

STREAM SURVEY RESULTS

Predicted surface areas of available rearing habitat (average annual 15-day summer low flow) for each major reach of the Lemhi River are qiven in Table 3.7. These predictions are for both prevailing (Options A and C) and enhanced (Options B and D) stream flows. These options are explained in Chapter 5. The enhanced stream flows were determined in an effort to improve upstream passage conditions for returninq adult fish. However, Table 3.7 shows the enhanced stream flows have no effect on the availability of rearing habitat in Reaches 2-5; none of the four options proposed will increase stream flows in these reaches.

Table 3.8 presents the surface areas of available rearing habitat in the major reaches of Hayden Creek and Big Springs Creek.

TABLE 3.7

REARING HABITAT FOR ANADROMOUS SALMONIDS (SQ YD)
UNDER PREVAILING AND ENHANCED STREAM FLOW CONDITIONS

REACH	POOL	RIFFLE	RUN	POCKETWATER	SIDECHANNEL	BACKWATER	TOTAL
1							
Prevailing	15,774	145,440	56,986	1,285	4,029	2,025	225,539
Enhanced	(15,774)	(174,379)	(59,770)	(1,212)	(3,878)	(2,725)	(257,738)
2							
Preva ling	29,535	213,569	73,469	1,340	2,215	831	321,050
Enhanced	(29,535)	(213,569)	(73,560)	(1,340)	(2,215)	(831)	(321,050)
3							
Prevailing	3,215	109,466	17,187	157	180	574	130,779
Enhanced	(3,215)	(109,466)	(17,187)	(157)	(180)	(574)	(130,779)
4							
Prevailing	30,000	240,469	125,612	500	4,442	950	401,981
Enhanced	(30,000)	(240,469)	(125,612)	(500)	(4,442)	(950)	(401,981)
5							
Prevailing	31,508	59,834	47,445	222	4,297	2,880	146,195
Enhanced	(31,508)	(59,834)	(47,445)	(222)	(4,297)	(2,880)	(146,195)

TABLE 3.8

SURFACE AREAS (SQ YD) OF HABITAT TYPES
IN BIG SPRING CREEK AND IN HAYDEN CREEK

STREAM REACH	POOL	RIFFLE	RUN	POCKETWATER	SIDECHANNEL	BACKWATER	TOTAL
Big Springs Creek	497	23,797	10,220	0	517	290	35,321
Upper Hayden Creek	150	20,947	313	860	0	0	22,270
Lower Hayden Creek	9,042	71,620	10,046	104,288	1,113	217	198,326
Hayden Creek	9,192	92,567	10.359	107,148	1,113	218	231,596

CHAPTER 4

DESCRIPTION OF ALTERNATIVES

This chapter describes the nine enhancement alternatives, presents potential problems, and estimates capital and annual costs. This chapter also presents characteristics of the alternative that would create a fisheries benefit. These characteristics are used to calculate benefits in Chapter 5.

ALTERNATIVE 1 - FLOW CONCENTRATION

The purpose of the flow concentration alternative is to provide a series of diversion dams and channel improvements that will concentrate the flow of the Lemhi River into the thalweg, thereby improving upstream and downstream passage.

ALTPRXATIVE DESCRIPTION

Present Practice

To ensure adequate flow is diverted into irriqation ditches, present practice in the Lemhi Valley consists of creating rock berms in the River from riverbed materials. In many locations, these berms extend across the River spreading the undiverted flow over the ent ire channel width. Excess diverted water is allowed to return to the River throuqh "wasteways," usually located a short distance downstream of the diversions. Wasteways do not have sufficiently defined channels to provide for fish passage. All these factors make fish passage difficult at some of the irrigation diversions.

Flow Concentration

The flow concentration alternative involves constructing permanent concrete diversion structures and fishways, replacing irrigation headgates, providing flood control levees, and channelizing River flows at several critical locations where fish passage difficulties have been observed. Table 4.1 defines the critical passage locations addressed in this alternative. Maps in Appendix B show locations of the structures and channelization of the streambed.

Diversions

The diversion structure would be a permanent concrete weir placed across the River. Figures 4.1 and 4.2 give details of a typical diversion structure. The typical concrete weir is 4 feet high and l-1/2 feet thick: weirs of slightly different height might be required at some locations. Water would spill over the weir onto a downstream apron which is 10 feet wide. Cutoff walls and riprap armoring would be placed at the downstream edge of the apron, to prevent undermining of the structure. A 4-foot wide sluiceway with stoplogs placed adjacent to the fishway would be provided at each site. The large amounts of gravel transported in the Lemhi might require a gate instead of stoplogs to flush gravel downstream. This should be considered during design. Weir dimensions for each critical location are given in Table 4.1.

Fishways

A concrete fishway would be placed at each of the proposed diversion structures. Fishways would provide passage for upstream adult migrants and assist downstream passage for migrating juvenile salmon and steelhead. The fishway would be a weir and pool design with 6-foot wide by 8-foot long pools. Pool depth would be 3-1/2 feet, and would provide a minimum fishway flow of

TABLE 4.1

SITE DATA FOR FLOW CONCENTRATION

REF. NO[1]	SITE NAME	LEMHI RIVER MILE	DIVERSION WIDTHS[2] (FT)	LEVEE HEIGHT[3] (FT)	LEVEE LENGTH[4] (FT)	CHANNEL LENGTH[5] (FT)	CAPITAL FIRST COST[6] $)	ANNUAL COSTS O&M ($)	ANNUAL COSTS CHANNEL ($)
1	SPSl	1.30	NA	0.0	0	300	N.A.	N.A.	390
2	L-3	3.30	NA	0.0	0	200	N.A.	N.A.	260
3	SPS2	3.90	NA	0.0	0	200	N.A.	N.A.	260
4	sPS3	5.40	NA	0.0	0	200	N.A.	N.A.	260
5	L-5	7.20	65	5.6	1485	200	462,000	3200	260
6	L-6	7.40	65	5.6	1485	200	462,000	3200	260
7	L-7	8.30	65	5.6	1485	200	462,000	3200	260
8	L-20	16.70	80	5.6	1491	200	470,000	3200	260
9	L-22	17.40	100	3.0	789	200	245,000	3200	260
10	L-31A	25.80	65	5.8	1547	200	487,000	3200	260
11	L-40	30.00	75	5.4	1431	200	441,000	3200	260
12	L-41	30.30	75	4.1	1094	200	318,000	3200	260
13	L-43	31.90	60	2.6	694	200	203,000	3200	260
14	L-44	33.70	55	2.8	752	200	214,000	3200	260
15	L-45D	36.90	90	2.7	733	200	227,000	3200	260
16	SPS4	48.60	NA	0.0	0	150	N.A.	N.A.	200
17	L-61	49.30	30	3.2	860	200	228,000	3200	260

1 Refer to location maps, Appendix B.

2 Diversion widths are based on bank full widths at nearhy locations.

3 Based on a SO-year flood flow extrapolated from the gate near Lemhi.

4 Assumes an average channel slope of 0.0075 and a levee slope of 0.00375.

5 At SPS (Supplemental Passage Stations) this channel length equals the riffle length (Buell in letter to OTT dated 8-16-85) plus 100 feet, rounded to the nearest 50 feet. All other stations are 200 feet.

6 Based on Figures 4.1 and 4.2 and example detailed cost summary on Table 4.2.

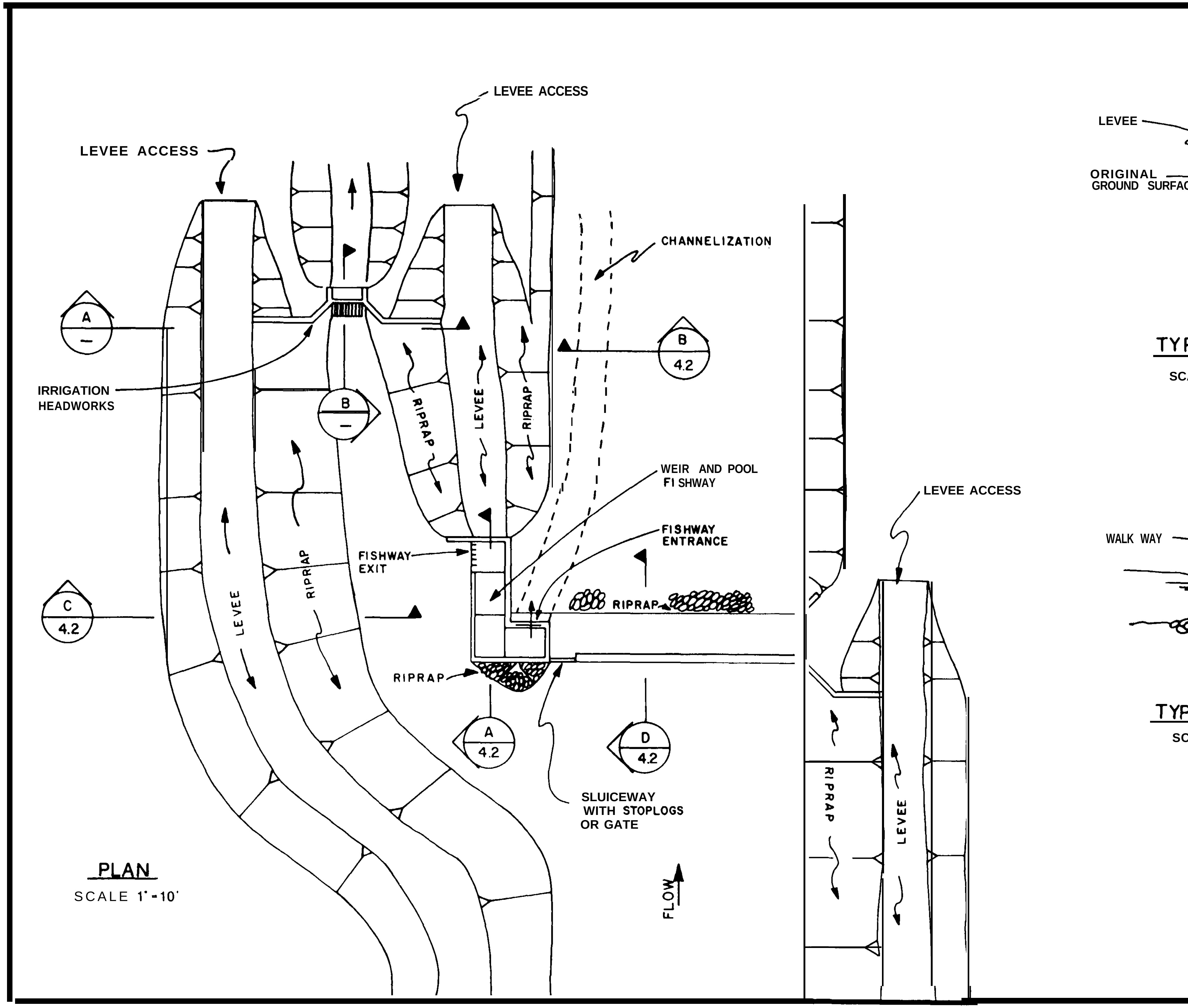


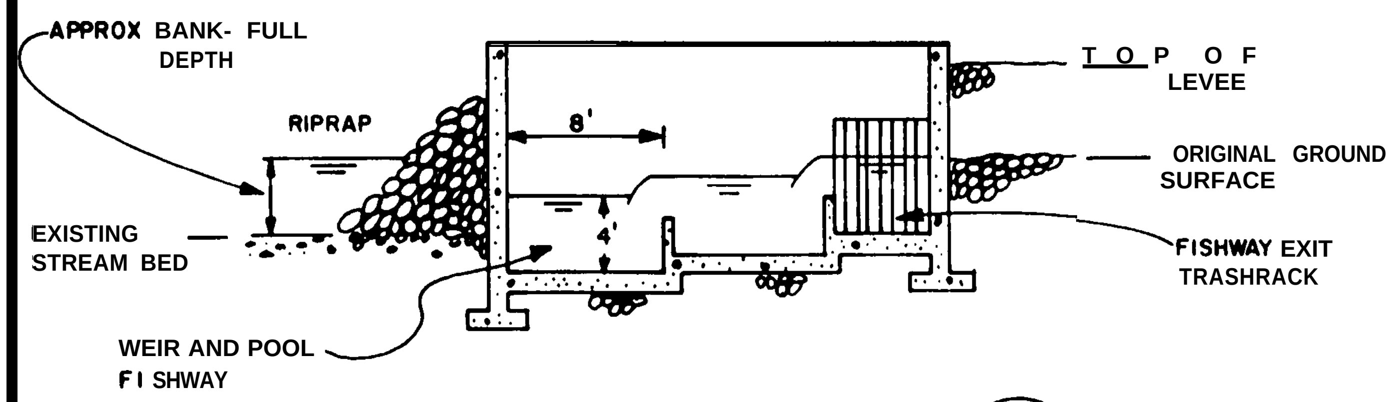
FIGURE 4.1

LEMHI RIVER
HABITAT IMPROVEMENT STUDY

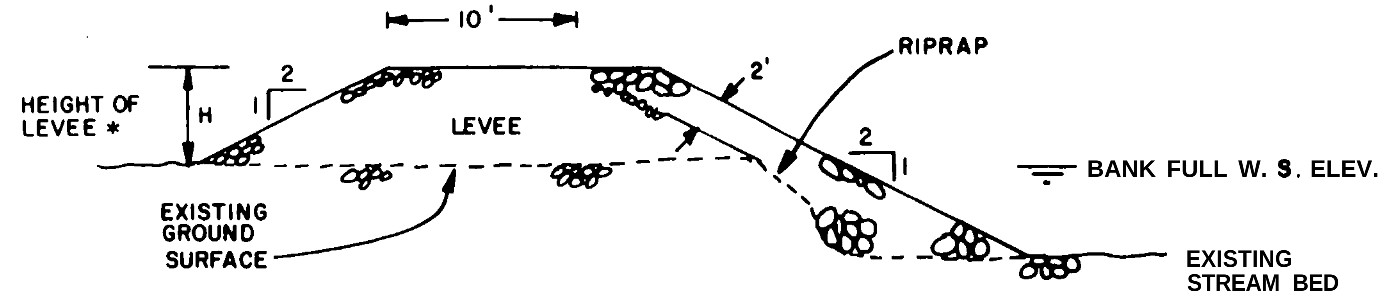
TYPICAL PLAN VIEW

DATE: NOVEMBER 1985

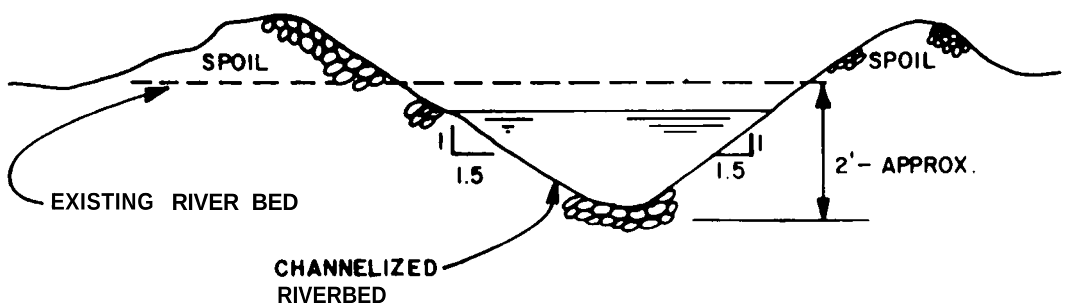
JOB NUMBER: S1028.03



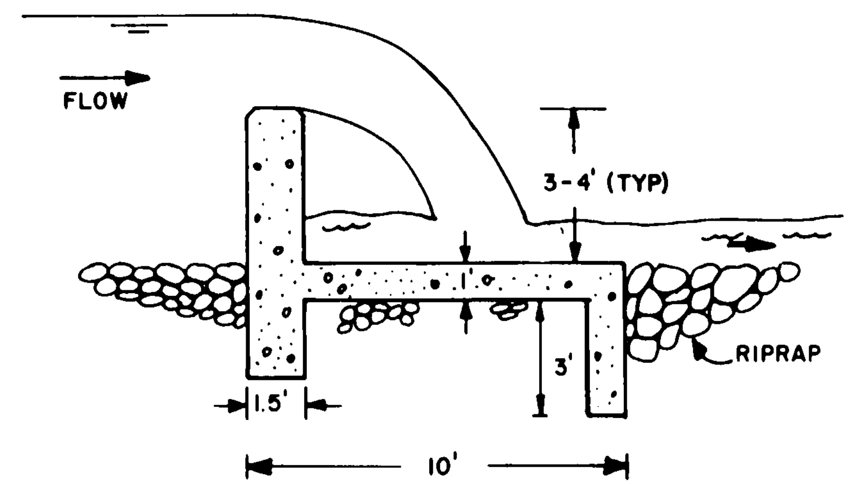
TYPICAL SECTION A/4.1
SCALE 1" = 10'



TYPICAL SECTION C/4.1
SCALE 1" = 10'



TYPICAL CHANNELIZATION SECTION B/4.1
SCALE 1" = 10'



TYPICAL SECTION D/4.1
SCALE 1" = 5'

* SITE SPECIFIC VALUES FOR HEIGHT OF LEVEE ARE SHOWN IN TABLE 4.1

FIGURE 4.2

LEMHI RIVER
HABITAT IMPROVEMENT STUDY

TYPICAL SECTIONS

DATE : NOVEMBER 1985
JOB NUMBER: S1028.03

OTT

10 cfs. At higher fishway flows, stoplog weirs can be adjusted to maintain the required energy dissipation in each pool. Details of the fishway are presented in Figures 4.1 and 4.2. Water rights for the fishways should be obtained.

Levees

Due to backwater effects the permanent diversion structures would produce higher upstream water surfaces during flood flows. To protect adjacent lands from increased flooding, levees would extend upstream from each of the diversion structures. The typical levee height was determined using a SO-year flow extrapolated from the USGS gage near Lemhi, Idaho and a freeboard of 2 feet. Typical levee placement and cross section are presented on Figures 4.1 and 4.2; specific dimensions for each levee are shown in Table 4.1. Riprap placed on the river side of the levee would provide protection from scour. Each levee would have a top width of 10 feet for vehicular access.

Headgates

Irrigation headgates would be constructed at each new diversion site. These headgates would provide a more efficient and permanent method for irrigators to adjust irrigation withdrawals, without placing or removing stoplogs in the fishway or dam. Typical structures would consist of a I-foot by I-foot vertical slide gate, trashrack, and concrete wing walls, which extend into both banks. Trashracks would be located at the upstream end of the wing walls and placed at a 30-degree angle to vertical.

Channelization

In addition to the diversion structures, the stream channel would be excavated downstream of each diversion structure, and at several other reaches, to concentrate flows where passage problems have been identified. Channels would be constructed during critical low-flow periods. Figure 4.2 illustrates a typical channel. A special blade on a dozer would be used to excavate the channel. At critical reaches, other than those located at diversion structures, it is assumed the channel length would be 100 feet longer than the identified riffle length. Total channel lengths are given in Table 4.1.

ANALYSIS

Design Considerations

Conceptual design of the diversion structures, fishways, and channelization is based on the following:

- Upstream and downstream fish passage
- Irrigation requirements
- Operation, maintenance, and dependability

The design of flow concentration facilities is based on fish passage requirements. Fishways would allow migration all year, while channelization would provide both upstream and downstream passage through impassable riffles during low-flow periods. Passage problems for downstream migrants are not anticipated at diversion structures during average flow periods.

Operation

Operation and maintenance costs are estimated for routine maintenance and for adjustments to the fishway. The diversion would require maintenance only for sluicing sediments and for inspection. The IDFG would be responsible for maintenance and for performing routine adjustments to fishways. Local irrigators would maintain operational control of irrigation headgates.

Data and Assumptions

Data

Information used for the conceptual design and analysis of this alternative includes hydrologic, cost, and field data. Much of the hydrologic and cost data used for assessing this alternative are presented in Chapter 3. Some additional costs were estimated, and 15-day low flows were developed for average years and recurrence intervals of 2, 10, 20, and 50 years. These data were used to evaluate the benefits of flow concentration. Field data used in the analysis include river width measurements and observations of low-flow problem areas.

Siting

A total of 17 sites have been identified for flow concentration and are presented in Table 4.1. Diversions L-6, L-7, L-20, L-31A, L-41, and L-61 are all critical diversions identified by IDFG. Diversions L-3 and L-45D were identified by OTT staff as critical passage sites which require only channelization. The remaininq sites are "supplemental passage stations" (SPS) and diversions identified as critical by Buell & Associates, Inc. during their field work.

Costs

Cost estimates were prepared using unit costs presented in Appendix E and quantities were taken from the conceptual drawings. cost estimates have been prepared separately for each site. Table 4.2 is a summary of capital and annual costs for a typical diversion structure (diversion L-5). Capital costs are those incurred at the beginning of the Project, including construction, engineering services, and equipment. Annual costs include operation and maintenance (O&M) and channelization.

TABLE 4.2

DETAILED FIRST COST SUMMARY
FOR DIVERSION L-5[1]

Quantities are based on the Typical Diversion Structure and Irrigation Headgate in Figures 4.1 and 4.2.

CAPITAL COST

ITEM	UNIT	QUANTITY	UNIT COST $/UNIT	TOTAL COST ($)
MOBILIZATION	LS	---	------	2,000
DEWATERING	LS	---	------	3,000
EARTHWORK[2]				249,200
Common:				
Excavation (trench)	CY	450	6.00	2,700
Backfill (select)	CY	305	2.00	610
Riprap (material)	CY	27	15.00	400
(placement) mi)	CY	27	20.00	540
(hauling-50		27	12.00	320
Levee:				
Fill (material)[3]	CY	6480	8.50	55,100
(hauling-30 mi)	CY	6480	4.00	25,900
Riprap (material)		3480	15.00	52,250
(placement)		3480	20.00	69,600
(hauling-50 mi)	CY	3480	12.00	41,800
CONCRETE				43,800
Structural-reinforced	CY	125	350.00	43,800
METALS				9,000
Trashrack	LS	1	-------	1,000
Slide Gate	LS	1	-------	8,000
WOOD				1,000
Stoplogs	LS	---	-------	500
Fishway Trashrack	LS	1	-------	500
SUBTOTAL				308,000
20% Engineering & Administration				61,600
30% Contingency				92,400
TOTAL CAPITAL COST				462,000

Table 4.2
(continued)

ANNUAL COST

Operation and Maintenance	$3,200.00
Channelization (200 ft)	260.00

1 Diversion L-5 is used for example in this detailed summary. Site-specific information for other sites is presented in Table 4.1.

2 Unit costs for excavation and backfill are adjusted to reflect costs for small quantities.

3 Unit price for levee fill is comprised of 50% engineered-select and 50% common. Hauling applies only to the engineered-select volumes.

Operation and maintenance costs per site include installation, major adjustments, and routine maintenance. Upstream migration lasts for approximately 22 weeks. During this period, labor for routine facility maintenance and adjustments to the fishway requires an estimated 14 man-days. An additional 5 man-days per year will be reauired for facility inspection, repair, and sluicing. Assuming an employee rate of $128 per man-day, the total annual O&M cost for 19 man-days per site is approximately $2,430. Adding a 30 percent contingency results in approximately $3,160 per site.

Annual cost for channelization accounts for bulldozer rental and operation. It is estimated that excavating 200 feet of channel takes one hour per site, assuming several sites are excavated per day. Because the diversion structure is in place during high flow periods, channel excavation might be reauired twice every year. Assuming the rental of a bulldozer with an operator costs $100 per hour and a 30 percent contingency, the total annual channelization cost is $260 per site.

RESULTS

Cost

The total capital cost for developing the 12 diversion structures at the locations given in Table 4.1 is $4,219,000. The total annual O&M cost is approximately $38,000 in the first year. Annual cost for channelization at 17 locations is $4,490.

Implications for Fish

Benefits from this alternative are based on the increase in fish production through more efficient upstream passage. For this reason the conceptual designs of diversion structures and channelization were developed. The most critical location for passage over the new diversion is the approach through the channel. It is assumed that when upstream migrants reach the fishway entrance, they are able to negotiate the fishway and proceed upstream. The effects of icing in the pool upstream of the dam should be addressed in future detailed analyses. Channelization of flow during critical low-flow periods is required for passage upstream to the fishway. Utilizing depth criteria for passage, the computed minimum flow for the excavated channels is 6 cfs, for a depth of 1.5 feet in the typical channel illustrated on Figure 4.2.

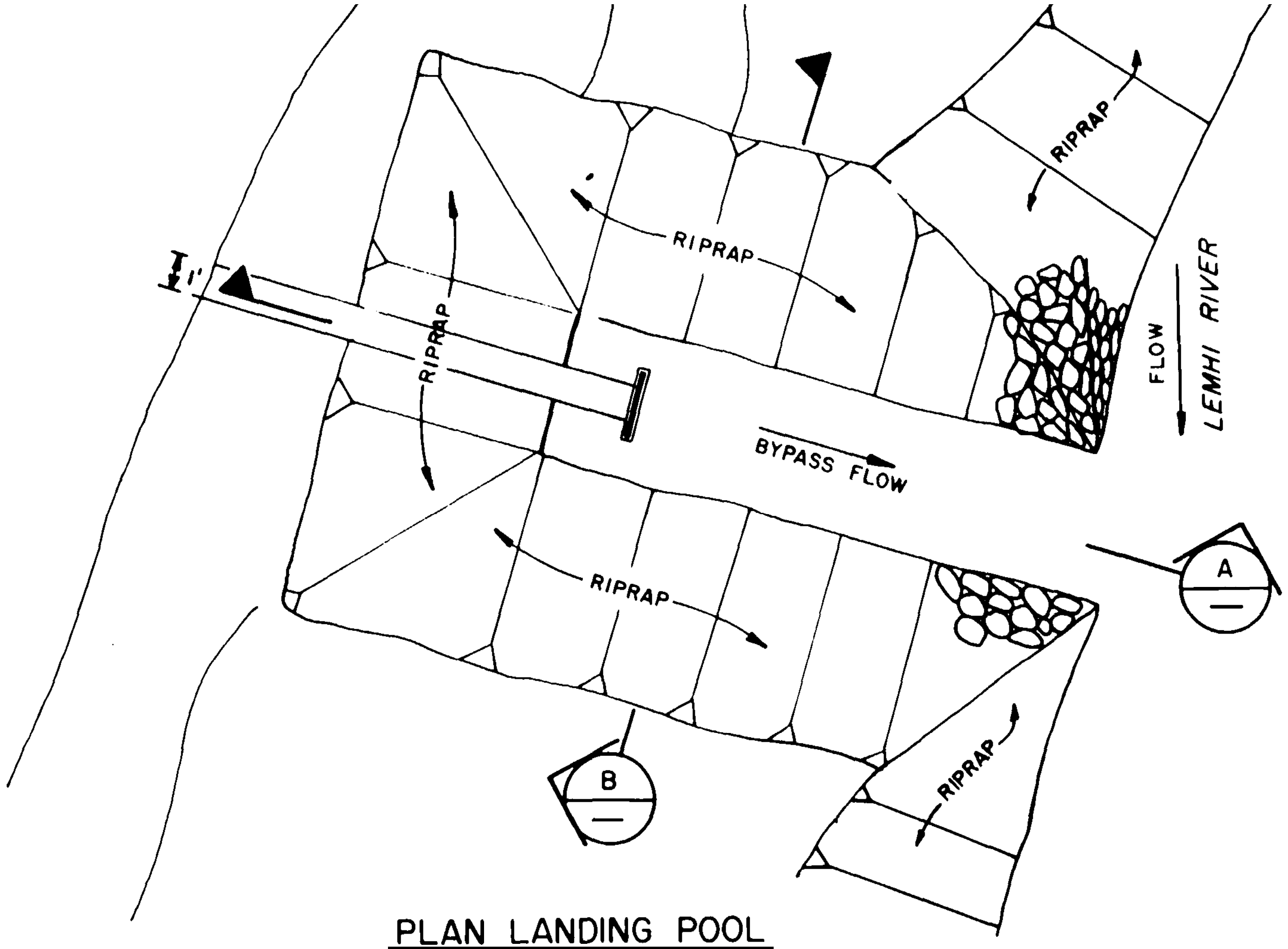
ALTERNATIVE 2 - FISH SCREEN IMPROVEMENT

Historically, low flows and high irrigation demands have greatly reduced the downstream passage efficiency of chinook and steelhead through the Lemhi system. Fish are diverted into irrigation intake canals where they encounter fish screens and are either channeled back to the River or experience significant delay because of their inability to find bypass pipes. This task suggests ways for reducing mortality when downstream migrating juveniles encounter screening devices.

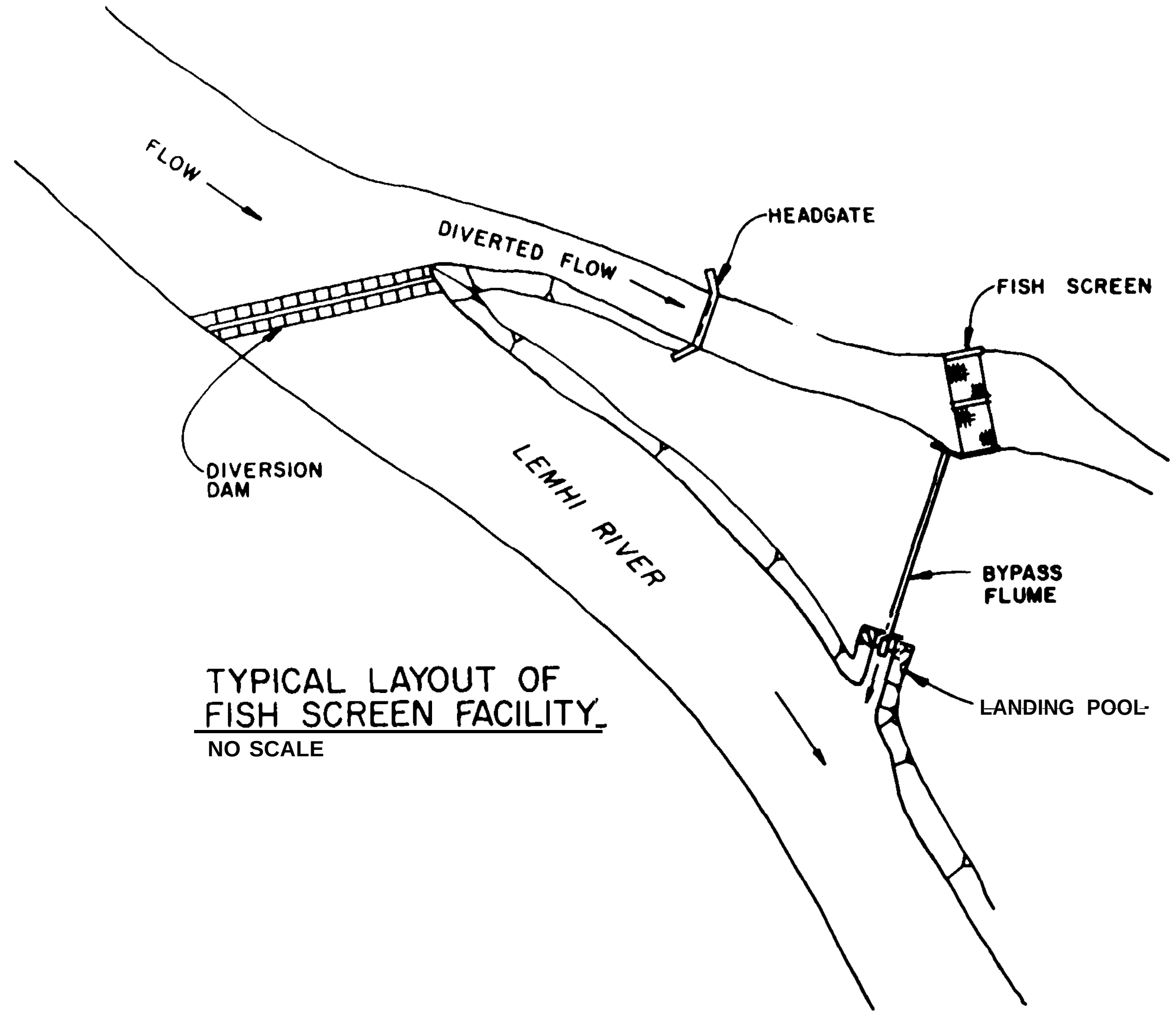
ALTERNATIVE DESCRIPTION

Existing Screening Facilities

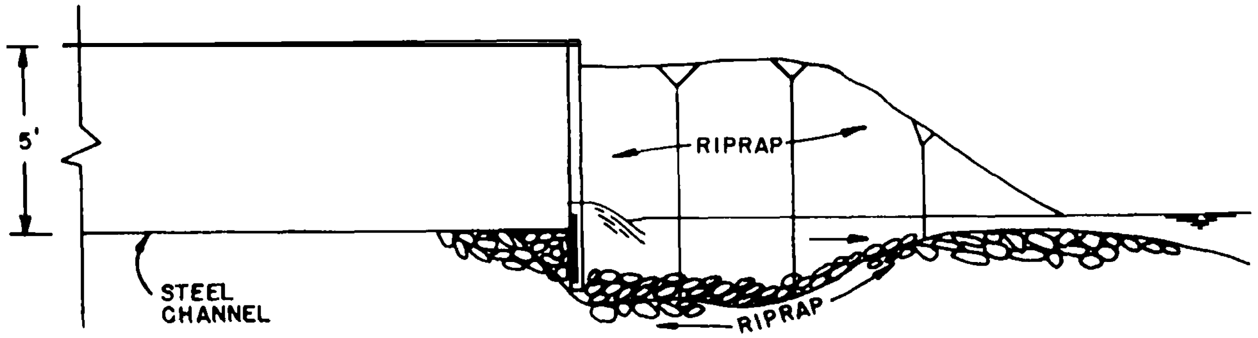
Most diversions on the Lemhi are equipped with fish screens to prevent the entrapment of fish in canals. Typically, water is diverted into a canal intake adjacent to the River by a small diversion dam. Headgates, located just upstream from the screens, are used to control the amount of water diverted through the screens into the irrigation canals. Figure 4.3 illustrates a typical diversion layout. To ensure that water will not be stopped if the screens become blocked, a bypass gate is provided at each facility. A trip mechanism opens the bypass when the



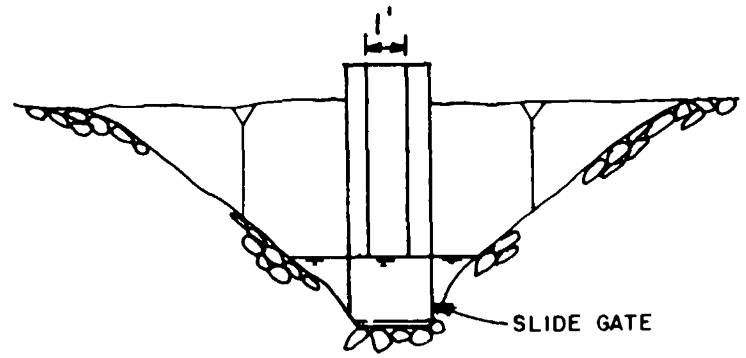
PLAN LANDING POOL
SCALE 1" = 5'



TYPICAL LAYOUT OF FISH SCREEN FACILITY
NO SCALE



SECTION A
SCALE 1" = 5'



SECTION B
SCALE 1" = 5'

FIGURE 4.3
LEMHI RIVER HABITAT IMPROVEMENT STUDY FISH SCREEN BYPASS
DATE: NOVEMBER 1985 JOB NUMBER: S102B.0 3

OTT

below the water surface, connecting the area in front of the screens with the River. Several difficulties are associated with these bypasses. It appears the principal difficulty is the inability of a small bypass pipe and low bypass flow to attract larger steelhead smolts and pass them back to the River. During field visits, OTT found that several of the pipes were discharging onto the River bank or were plugged.

To accommodate more flow in the bypass, it first would be necessary to obtain a new water right. This new water right could only be exercised in times of excess flow, because most irrigating rights on canals have priority. During the downstream migration periods, there often is additional flow that would be available for the bypass.

ANALYSIS

Efficiencies of Existing Screens

Bjornn performed an analysis of the effectiveness of fish screens on the Lemhi (Bjornn and Ringe, 1984). The data did not permit an in-depth analysis able to quantify efficiency of the individual screens. Bjornn's study with steelhead smolts found approximately 10 percent of downstream migrants successfully reached the Salmon River after being released in the Lemhi, a short distance above the Hayden Creek confluence. No studies were found estimating the screen efficiency of chinook outmigrants at individual diversions or screening locations.

There are approximately 40 screening systems located downstream of Hayden Creek. A fish passage efficiency is associated with each screen. The total efficiency is the product of each screen efficiency. Studies to compute individual efficiencies would be extremely difficult and costly. The best approach would be to perform controlled experiments on different types of bypasses.

hydrostatic gradient between the upstream face and downstream face of the screen reaches a critical level. A fish bypass pipe, four to six inches in diameter, is placed at each screening facility. Downstream migrants approach the screens and move laterally along the face of the screen until they detect the entrance to the pipe and are carried through the pipe back to the River.

The two types of screening facilities used on the Lemhi are the perforated plate screen and the drum screen. The perforated plate screen consists of a vertical plate aligned at an angle to the canal flow. The screen is cleaned by vertical scrapers or brushes that travel across the screen face. A paddle wheel which is turned by water flowing in the canal, operates the scrapers. This type of screen configuration does not allow debris removal: therefore, periodic maintenance is required to keep the screen in operation.

Drum screen facilities consist of one or more wire mesh drums. The drums rotate about a horizontal axis and are powered by an electric motor. Where electricity is not available, drum screens are installed with paddle wheels. Water enters through the upstream face of the screen. Debris is caught and lifted out of the water by the rotation of the screen. It is then washed off the screen as it rotates to the downstream face. These screens require less maintenance than the perforated plate type and are more reliable. Since debris is actually cleared from the upstream face of these screens, it is less likely that a hydrostatic pressure differential will be created across the screen and cause the bypass gate to open and allow fish to move into irrigation ditches.

Existing Fish Bypass System

The fish bypass arrangement at the screen facilities consists of either a 4-inch or 6-inch PVC pipe, located approximately 2-3 feet

RESULTS

Five steps are recommended for improving fish screen efficiency on the Lemhi.

1. Controlled Experiment. A controlled experiment is necessary to determine the most effective bypass system for the type of screens on the Lemhi. The experiment would take place at the trap facility upstream of the confluence of Hayden Creek. It would involve installing a prototype rotating drum screen and a facility for testing different types of fish bypass structures. Chinook and steelhead smolts would be used in the experiments to test the efficiency of various bypass structures (Figure 4.3).

2. Prototype Installation. After the controlled experiment is complete and the most effective bypass alternatives are identified, a prototype bypass system would be installed at a drum screen installation. This bypass system would also include training walls to provide a better transition to the bypass conduit.

3. Prototype Experiment. An experiment would be performed on the prototype system, testing the screen efficiencies for various bypass systems (identified in the controlled experiments and installed in the prototype).

4. Bypass Water Right. More flow might be required in the bypass to ensure it operates correctly. This would entail applying for a water right. Since this would be a junior right, it would be only available during periods of excess flow.

The fish trap facility, located just upstream of Hayden Creek, would be a suitable location for these experiments. Once the most efficient type of bypass system is identified, a prototype bypass could be installed at a screening facility.

Present Screening Program

The screening program financed by the National Marine Fisheries Service (NMFS) consists of installing screens at unscreened diversions, upgrading existing perforated plate screens with rotating drum screens, and performing daily maintenance for these screens. During field visits to the screening facilities, OTT noted the perforated plate screens were difficult to keep clean, since there is no provision for bypassing debris. The drum screens are quite reliable and relatively maintenance free. The program also calls for a more uniform screen design to improve maintenance. The fish screen portion of the drum screen facilities were adequate. The best improvement alternative would be to accelerate the replacement of perforated plate screens with drum screens.

Bypass Structure

OTT recommends an experimental bypass structure be constructed for experiments of bypass efficiencies. It should be installed at a drum screen facility with a relatively short distance between the screen and the River. The bypass would consist of a rectangular-shaped channel prefabricated from steel or aluminum, approximately 12 inches wide and 5 feet high. The channel would be buried with its upstream end located in the pool, upstream of the drum screen, while the downstream end would be located in a pool excavated into the River bank (Figure 4.3). It would have the capability of accepting inserts to create a pressure conduit at any location in its S-foot depth, or an open-channel chute at the top of the bypass. This conceptual configuration could be altered, based on the results of controlled experiments.

Other Considerations

During field investigations, many instances of poorly maintained and operating screen facilities were identified. The perforated plate screens at L-8A and L-9 are examples. In addition, many of the bypass pipes are excessively long or difficult to find. Accelerating the NMFS program would improve conditions, but for the present, screen maintenance should be emphasized in aiding juvenile passage.

ALTERNATIVE 3 - GROUNDWATER AUGMENTATION

The purpose of direct groundwater augmentation to the Lemhi River is to prevent situations where steelhead and chinook migrating upstream or downstream are blocked or excessively delayed. The objective is to augment stream flow to a level at which minimum flow requirements would be achieved.

DESCRIPTION

Wells for directly augmenting stream flow would be located in the vicinity of identified "critical" or "problem" River reaches. The actual siting of a single well or group of wells would be based on the suitability of the aquifer to provide additional flow without affecting existing wells. Water would then be transported through buried low pressure or gravity flow pipelines to the critical site. The total flow requirement of these wells would be determined by the difference between minimum instream flows for fish passage and stream flow available during low-flow periods.

ANALYSIS

The analysis presented in this section is basic to the alternatives which include the use of groundwater. An evaluation of relevant geologic and groundwater parameters is presented in

5. Upgrade Screen Program. The present fish screen program would need to be upgraded and accelerated to incorporate the bypass system which proves to be most efficient in the controlled and prototype experiments.

Costs

The estimated costs for the recommended programs are given in the table below. The contribution to the screen upgrade program would vary with the bypass structure effectiveness determined in the experiments.

Program	Cost
Controlled Experiment Construction	$ 15,000
Controlled Experiment	15,000
Prototype Construction	20,000
Prototype Experiment	25,000
Water Rights Application	5,000
Contribution to Screen Upgrade	300.000
Total Cost	$380,000

Implications for Fish

Because of insufficient data the benefits associated with fish screen facility improvements could not be computed. Data on the efficiencies of possible screening alternatives can only be assessed by controlled tests in the Lemhi. For purposes of evaluating screen improvements as a fisheries management alternative, it was assumed that a 75 percent basin-wide improvement in diversion passage conditions could be achieved in the Lemhi River Basin. Chapter 5 addresses the screen improvement alternative in greater detail.

There is sufficient evidence that a significant downstream passage problem does exist. More efficient screening facilities could increase significantly the proportion of outmigrants reaching the Salmon River.

RESULTS

Total Alternative Yield

Using observed specific capacity and yield values, the total availability of flow can be estimated. Assuming that sustained yield is equal to specific capacity, 300 wells with a specific capacity of 0.067 cfs, pumped for 24 hours a day, would be necessary to meet a supplemental flow of 20 cfs, which is the minimum flow below L-5. If we assume a sustained yield equal to the maximum yield in the Valley, 300 gal/min or .67 cfs, then 30 wells would be required to draw a total of 20 cfs. The cost estimates given below are based on this latter assumption of requiring 30 wells to satisfy fish passage requirements.

Cost

Assuming the average well depth is 100 feet, with a 12-inch diameter, and using the cost equations from Chapter 3, the cost of this alternative would be:

30 wells x $1,300.00 (cost of volume pump)	=	$ 39,000.00
30 wells x $ 200.00 (cost of 2 hp motors)	=	$ 6,000.00
30 wells x $4,000.00 (cost of drilling)	=	$120,000.00

Total costs for drilling, pumps, and motors = $165,000.00

These cost estimates do not include: geophysical examination, aquifer tests, test wells, pipelines, roads, excavation, power-lines, land, and water rights. The capital cost could be expected to double at a minimum.

It is possible that this alternative could be implemented in conjunction with channelization. An additional flow of 6 cfs at critical points would be required to supplement the channelization alternative.

Chapter 3. Well location, groundwater availability and yield, and specific site yields are also presented in Chapter 3.

Well Location

Without intensive examination of geophysical characteristics and detailed aquifer tests, the exact location of wells required for alternatives involving the use of groundwater cannot be determined. The type and location of tests would have to be resolved through further study, field investigation, and meetings with agency personnel.

Groundwater Availablity and Yield

Groundwater Yield

In evaluating the availability of groundwater at critical sites, OTT applied Darcy's Law using generalized conditions. Because a detailed aquifer analysis has not been performed, assumptions were made to simplify the models.

Based on theoretical conditions, the following availabilities can be expected from the aquifer in the vicinity of critical River reaches (identified by proximity to diversions):

L6 - 0.87 cfs
L7 - 0.89 cfs
L20 - 0.97 cfs
GAGE - 0.32 cfs
L41 - 0.58 cfs

There is a wide range in well capacities at currently-operating wells in the Valley. Reported well yields from the U.S. Geological Survey are from 1 to 300 gal/min (0.67 cfs) with specific capacities ranging from 1 to 30 (gal/min) (.067 cfs).

In order to achieve the objectives of this alternative, water right purchases or formal changes in the method of withdrawal would need to be implemented. The options available are:

1. Purchase and install wells and pumps for the Town Ditch Company to replace a portion of the total surface water diversion into these ditches with groundwater withdrawal. Current flood irrigation practices would be retained.

2. Approach individual land owners to negotiate replacing all or a portion of their surface water right for groundwater withdrawal rights.

3. Approach individual land owners and offer to purchase a portion of their water right, and negotiate to replace the remaining surface water right with qroundwater. Benefits from this exchange could then be used by the irrigator to purchase sprinkler systems or improve field or ditch conditions.

ANALYSIS

A major portion of the analysis for this alternative is derived from the groundwater investigation and augmentation analyses. Basic concepts relating to regional geology and soils are not presented again in detail.

<u>Geologic and Soil Factors</u>

Deep wells would be located in the Quarternary Tertiary sediments where available. In areas without such an aquifer source, groundwater withdrawals would consist of percolated water originally applied by flood irrigation. Under present conditions, most of this water reaches the River through infiltration. Well

Other Considerations

With this alternative, there is potential for conflict between flood irrigation in the Lemhi Valley and pumping groundwater on a large-scale basis. Installing numerous pumps in the lower Valley, where the aquifer is shallow, could interfere with the current practice of raising the water table by intense flooding of fields in the spring.

ALTERNATIVE 4 - GROUNDWATER IRRIGATION

The groundwater irrigation alternative involves replacing surface water diverted from the Lemhi with pumped groundwater. Fields could be irrigated by well water either through flood or sprinkler systems. The purpose of this analysis is to assess the economic and legal feasibility of pumping water for irrigation purposes on a larger scale than is currently practiced in the Valley.

ALTERNATIVE DESCRIPTION

This alternative involves replacing surface water with groundwater for irrigation on the River downstream of RM 8.6. This is because the contribution of flood irrigation to groundwater recharge in the upper Valley during the latter part of the irrigation season is essential.

Water can be withdrawn from deep wells in a confined aquifer or from shallow wells containing water recently used for irrigation. Wells should be located to avoid interference with irrigation. If sprinklers were installed to replace flood irrigation practices, site placement would be less important because of lower water requirements due to higher application efficiency. Wells could be installed on an individual user basis or on a larger scale for the Town Ditch Company in the Lemhi Valley. Limitations on these options are groundwater availability, water rights law, and other legal restrictions.

Cost to BPA

The unit cost to BPA is $17,000/cfs, based on a land value of $500/acre (the difference between land with and without water rights) and a water right allocation of 0.03 cfs/acre. As the following sections state, 12.5 cfs and 20.9 cfs could be conserved at a point below L-6 for flood and sprinkler irrigation systems, respectively. Therefore, the costs are $212,500 and $355,000 respectively.

Cost to Irrigator

The costs and benefits for area ranchers who sell partial or entire water rights depend on the type of irrigation system installed: flood or sprinkler.

For improved flood irrigation, benefits and costs per acre are as follows:

Water Use = 0.021 cfs/acre
Income from Water Rights Sale = $153/acre
Income from Yield Increase = $130/acre
Cost for Improvements = $250/acre
Cost for Pumps, Motors, and Drilling
= ($5,500/we11)(.021 cfs/acre)(well/.67 cfs)
= $172/acre
Annual Electricity Cost
= (.03 wells/acre)(6 kW)(24 hrs)(30 days)(6 months) ($.0438/kWh)
= $34/acre/year

Therefore,

	First Year	Annual
Income =	$283/acre	$130/acre
cost =	$456/acre	$ 34/acre

drawdown and interference is a determining factor in locating well installations. Well location is further confined by the site-specific nature of this alternative.

Water Rights

Several factors affect the feasibility of this alternative and those which follow. They involve water law and the ability of BPA to directly fund capital improvements for individuals or a quasi-public entity such as the Town Ditch Company. They are summarized as follows:

- RPA cannot expend funds to the benefit of an individual water user where there is no "Federal interest" in that land. Therefore, capital expenditures for improvements like sprinkler systems must be made by the water user in the exchange for purchasing water rights.

- Surface diversion water rights are an entirely different type of right than a groundwater right. It is uncertain how conflicts for water use would be resolved between different types and seniorities of water users, especially along a river such as the Lemhi that has been entirely adjudicated.

- When a change in the type of water right is made (i.e., surface water to groundwater), prior right dates are not retained.

Costs

The following flow availability and cost analyses are identical to those presented in the Water Withdrawal Reduction and Sprinkler Irriqation sections, except that costs associated with wells must be added. The cost to BPA is still based on the value of a water right.

yeilds due to improved water application. However, this gain probably would not offset pumping costs.

Implications for Fish

Approximately 13 to 20 cfs could be saved at L-6 and L-7 if enough irrigated acreage or water rights could be purchased by BPA.

Other Considerations

In evaluating this alternative, consideration must be given to water rights law. The most important aspect affecting public support probably will be that priority of right is not retained when changing the type of a water right from surface to groundwater.

ALTERNATIVE 5 - WATER WITHDRAWAL REDUCTION

Surface water diversions could be reduced by purchasing water rights directly from a landowner, or buying land with senior water rights and not diverting that water. The purpose of this section is to evaluate the feasibility of purchasing water rights and increasing flood irrigation efficiency.

ALTERNATIVE DESCRIPTION

In implementing this alternative, there are several distinct options:

1. Purchase land to which a senior water right is attached. Transfer this right from a surface water diversion for irrigation to an instream right for fish enhancement. Sell the land without the water right.

For sprinkler irrigation, benefits and costs per acre are as follows:

Water Use = 0.015 cfs/acre
Income from Water Rights Sale = $255/acre
Income from Yield Increase = $130/acre
Cost for Sprinklers = $245/acre
Cost for Pumps, Motors, and Drilling
= ($5,500/we11)(.015cfs/acre)(well/.67 cfs)
= $123/acre

Annual Electricity Cost
= (.022 wells/acre)(6 kW)(24 hrs)(30 days)(6 months) ($.0438/kWh)
= $25/acre/year

Annual O&M
= ($245/acre)(0.15) = $37/acre

Therefore,

	First Year	Annual
Income =	$385/acre	$130/acre
cost =	$430/acre	$ 62/acre

RESULTS

Cost

The total initial cost of the alternative to BPA is approximately $300,000 depending on how much water can be conserved through improved irrigation. Initial gross costs to irrigators are $456/acre for flood irrigation and $430/acre for sprinkler systems. Annual costs are inexact but are definitely higher for the latter option. Net gains by participating ranchers could be realized through an increase in the quality and quantity of hay the Idaho Water Resources Department (IWRD), Herndon Law Office, and local irrigators. Data were obtained from the Soil Conservation Service (SCS) in order to assess the parameters involved in increasing irrigation efficiency.

Available Flow Benefits

Water Rights Purchase

Flow available from the outright purchase of water rights or the purchasing and selling of land with and without rights, respectively, influences implementation of this option. The cost analysis is based on the likelihood of purchasing enough senior water rights in order to satisfy fish requirements. From this value, a total cost was computed based on an estimate of allocated water rights per acre.

Land Purchase

The amount of undiverted stream flow, produced by the direct purchase of land, depends on the amount of land available for sale. It would be preferable to obtain land with senior water rights, so that a priority can be established for maintaining stream flow for fish during dry periods. Cost estimates for this option assume that enough land can be purchased to satisfy a minimum flow of 20 cfs at diversion 1-5.

Irrigation Efficiency Improvement

The following estimates and assumptions are used in the analysis of benefits and cost:

- Current application efficiency in the Valley with flood irrigation (ungraded fields, generally long runs) is 20-30 percent, not including delivery losses.

2. Directly purchase a senior water right in its entirety for land parcels in the lower Lemhi Basin. Transfer to an instream right for fish benefits.

3. Purchase partial water rights from individual irrigators. Ranchers could then use the income from this sale to improve the efficiency of flood irrigation systems. Transfer purchased portion to an instream right.

4. Purchase land having senior water rights. Instead of selling the land without the rights, allow the acreage to revert to a natural state for wildlife habitat or convert the area to a park for public recreational use. Transfer the right to an instream right for fish.

In changing the beneficial use of a water right from irrigation to fish, the priority date remains unchanged because both are the same type of right. However, in altering the beneficial use, the user must conform with three basic rules: 1) no other water users will be impaired: 2) the amount of water withdrawal cannot be increased: and 3) the change is in the local public interest.

The only possibility for direct outlay of funds for increased water use efficiency would be to improve properties belonging to the Town Ditch Company. The Andrews and Town (or Slough) Ditches which extend from L-6 and L-7 and are 6.8 and 4.6 miles long, respectively, could be reshaped, compacted, and lined with bentonite, gunite, or perhaps polyethelene.

ANALYSIS

Data Sources

In order to analyze the feasibility of purchasing land or water rights, information was collected from numerous sources including:

Water Availability

If 30 percent of the current water withdrawals can be conserved under improved flood irrigation practices and 60 percent of the ranchers diverting from L-6 and L-7 participate, then water use reduction can be computed as follows:

Water Savings from L-7
= (water right)(% conserved)(% participation)
= (28 cfs)(0.30)(0.60)
= 5.0 cfs

Water Savings from L-6
= (41.8 cfs)(0.30)(0.60)
= 7.5 cfs

The sum of these values, 12.5 cfs, can be used to compute the cost to BPA.

Costs

Water Rights Purchase

The cost of a water right on a unit area basis was estimated as $500/acre for the lower Valley. This is the difference in the price of land with and without water riqhts. The unit price for a water right is extremely variable and depends on site-specific conditions. Using the estimated value for water savings downstream of diversion L-6, the total cost to BPA for this alternative can be calculated as follows:

Cost per cfs = (water value)(unit allocation at field)
= ($5OO/acre)(acres/0.03 cfs)
= $17,000/cfs

- Future application efficiency with improvements (leveled fields, shortened runs, improved layout) is approximately SO-60 percent, depending on management practices.

- Approximate water rights allocation at the field (not including amounts added for transport losses) according to IWRD adjudication is approximately .03 cfs/acre or 1.5-2.0 acre-feet per acre during the irrigation season.

- Current yield with flood irrigation is about 3 to 3-l/2 tons/acre (average for two cuttings of alfalfa-grass mixture hay in the lower Lemhi Valley under average weather conditions). Yield for grass hay under similar conditions is l-1/2 to 2 tons/acre.

- Predicted yields with improvements to flood irrigation practices are 5 tons/acre for alfalfa-grass hay and 3-4 tons/acre for grass hay.

Increased water application efficiency also increases the hay quality. This in turn means an increase in value or greater weight gains when fed to cattle.

Location

Because of the critical nature of the lower Lemhi River during low flow, efforts were concentrated in the Valley north of diversion L-8 in the low elevation areas. No consideration was given to the "benches" or bluffs which border the floodplain and Valley. These areas are sprinkler irrigated and soils have extremely high percolation rates.

the water rights purchase be cost effective for the participating ranchers to improve irrigation efficiency. On a per-acre basis for alfalfa-grass mixture hay, a feasibility analysis for the irrigator could be performed as follows:

Current Water Use
= 0.03 cfs/acre (based on allocation)

Amount Conserved
= (Water Use)(% Conserved)
= (0.03 cfs/acre)(0.30) = .009 cfs/acre

Income from Sale of Partial Water Right
= ($17,000/cfs)(.009 cfs/acre)
= $153/acre

Annual Income Increase Due to Yield Increase
= (5-3) tons/acre ($65/ton)
= $130/acre

Cost to Improve Land and Ditches
= $250/acre

Annual cost increases due to increased labor to manage water distribution is unknown; most ranchers do not hire workers for flood irrigation.

Canal Improvement

The cost of lining Town Ditch with gunite or polyethelene is approximated as follows:

Total Cost = (wetted perimeter)(length)(unit cost)
= (6 ft)(4.6 mi)(5280 ft/mi)($1.50/ft^2)
= $219,000

Total Cost = ($/cfs)(flow conserved)
= ($17,000/cfs)(12.5 cfs)
= $212,500

An assessment of the total number of acres which must be directly purchased in order to achieve this water reduction is as follows:

Total Acreage Required
= (12.5 cfs)(acre/0.03 cfs)
= 417 acres

Land Purchase

With this option, land would be purchased for the purpose of securing water rights, and would not be resold. Thus, the total and per unit cfs costs would be greater than for purchasing the water right only. If we assume an approximate cost for land with water rights of $l,5OO/acre, the total cost is calculated as follows:

Cost per cfs = (land value)(unit allocation)
= ($l,5OO/acre/cfs)(acre/.03 cfs)
= $50,00/cfs

Total Cost = ($/cfs)(flow requirement)
= ($50,000/cfs)(20 cfs)
= $1,000,000

Acreage Required = (20 cfs)(acre/.03 cfs)
= 667 acres

Irrigation Efficiency Improvements

The cost to BPA for this option would be equal to the purchase of a water right, $17,000 per cfs. However, it is imperative that exchange partial water rights for income to improve flood irrigation application. Benefits also depend on the availability of land with water rights for sale.

Additional benefits could be realized from this option if an area for game and nongame animals was established. If allowed to revert to a natural state, riparian areas would improve allowing greater benefit to the fish population.

ALTERNATIVE 6 - RETURN FLOW IMPROVEMENT

The purpose of this alternative study is to evaluate the feasibility of improving return flows from flood irrigation practices.

ALTERNATIVE DESCRIPTION

Return flow improvement sites would be located in areas with marshes or perched water tables, or areas downhill of intensely irrigated fields, suitable for catchment ponds or collection ditches. Emphasis should be placed on the lower Valley because critical reaches are concentrated there.

Improving the return flow process could involve several methods:

- Draining marsh and natural collection areas by placing pumps at these sites and installing pipes for transporting water to critical areas.

- Constructing collection ditches and catchment ponds to drain heavily-irrigated areas faster. Ditches would be parallel to the River along the floodplain in order to catch shallow groundwater. Catchment ponds could be drained with pipes or ditches using pumps or gravity flow.

This cost could be reduced by lining only portions of the canal or by using a local source of bentonite and local labor to perform the work.

Crop Yields

As previously mentioned, the option of purchasing partial water rights cannot be implemented without the participation of individual irrigators. For this reason, increased crop yields and quality are an essential factor for encouraging ranchers to negotiate water right exchanges.

RESULTS

Cost

The cost of this alternative would be about $17,000/cfs of water conserved, or $212,500 if 12.5 cfs can be conserved under assumed conditions of irrigation efficiency and water use. If land was purchased and retained by an agency, the cost would be $l,000,000 for water rights totaling 20 cfs.

A value for water rights on a per-acre basis is difficult to predict since there are many land uses and ranch sizes in the lower Valley. Ranches vary in size from 100-200 acres to a few extensive cattle ranches of l,OOO-2,000 acres. Land value also varies greatly with the appurtenances attached to the land such as houses, barns, equipment, or land characteristics such as soil and historic crop yields. These variables affect the cost of this alternative.

Implications for Fish

The flow benefits for this alternative depend on the willingness of local irrigators to participate. They must be willing to

Field surveys indicate that there are currently numerous return flows which contribute significantly to the River. An example is Geertson Slough, located between L-3B and L-4. During late July, this Slough was contributing approximately 2.0 cfs. Apparently, there are several ditches which augment the River at a nearly constant rate.

Water Quality

Water quality is an extremely important consideration for augmenting the River with return flows. Shallow groundwater, or water collected in ponds or slow moving ditches, will be warm and may contain agricultural chemicals. Since water temperatures in the lower Lemhi are high during low-flow periods, adding water of low quality would not be advantageous to enhancing fish populations.

RESULTS

The implementation of this alternative may adversely affect water quality in the River. In addition, insufficient data were available for an in-depth analysis. As a result, this alternative was discarded early in the Study.

ALTERNATIVE 7 - SPRINKLER IRRIGATION

The objective of this alternative study is to determine the feasibility of replacing flood irrigation with sprinkler systems to reduce total surface water diversion.

ALTERNATIVE DESCRIPTION

This alternative involves purchasing partial water rights in exchange for more efficient irrigation systems. Incentives for participation by area ranchers include increased yields and

- Installing drainage tiling in order to capture deep percolation and return excess flows to the River through pipes or ditches.

Because it involves improvement to private land, the latter option would be performed on a site-specific basis and would require an exchange between BPA and individual irrigators.

ANALYSIS

Data Sources

The major sources of data used in this analysis were field investigations and aerial photos. During reconnaissance surveys, marsh and other groundwater collection areas were identified, especially in the lower Basin. Aerial photos were used to locate natural water storage areas.

Groundwater Interaction

The aquifer system serves as a storage reservoir. Draining natural storage areas or installing artificial drainage could disrupt this process. The storage process appears to be essential for maintaining flows in the late summer. Because of the complex nature of the system, it is impossible, given the data available, to assess the impact on groundwater return flow when implementing this alternative.

Flow Availability

Quantifying the flow available in marsh areas, potential collection ponds, or ditches is difficult. In the lower Valley, there are no evident large, concentrated sources of water that can be easily drained. There are many small areas where the water table appears perched, but obtaining a consistent augmentation flow from these sources is questionable.

ANALYSIS

Data Sources

Sources of information for this analysis were included in the Soil Conservation Service (SCS) and conversations with area ranchers. Unit costs, shown in Appendix E, were used for evaluating this alternative.

Water Utilization and Conservation

Method of Withdrawal

Because groundwater irrigation was considered in previous sections, this analysis will address only the option of sprinkler irrigation from surface water diversions.

Water Use and Savings

Currently, water rights are allocated at approximately 0.03 cfs/acre at the field. A number of variables were considered in determining allocations, including diversion and transport losses. In conducting a general analysis, assumptions included:

- Of the standard water right allocation, 100 percent is currently required to flood irrigate a field.
- Transport losses are not considered.
- Future application efficiency with sprinklers (wheel lines) is approximately 70 percent.
- At least a 50 percent reduction in water use could be realized if inefficient flood irrigation is replaced by sprinklers.

monetary compensation for reduced water consumption. Proving the feasibility of this alternative to individual irrigators is essential to its success. To the irrigators, it is the bottom line that will determine whether they will sell part of their water rights.

Location

Low flows and high irrigation demand combine to create impassable reaches, generally downstream of diversion L-8 during May, late July, August, and September. Therefore, the lower Valley was identified as the area where sprinkler irrigation would provide the most benefit.

Implementation

Ranchers in the lower Basin would be solicited to participate in the program. A detailed design then would be developed for the specific sites, determining more accurately the required amount of water as well as the volume that could be saved during the irrigation season. This would indicate the amount of water right BPA should purchase: the value of that partial water right would determine whether the program was feasible for an individual site. A feasibility analysis would consider increased yields for ranchers. The site analysis during the design phase would be a more detailed version of the evaluation presented in this report. That analysis also should cover the interaction of applied irrigation water and groundwater. A switch to sprinklers on an upstream field might increase the irrigation requirements to a downstream field. Once an agreement was reached, the water right would be purchased and formally transferred to an instream right for the benefit of fish.

Cost to Irrigator

Based on the analysis performed for Alternative 5, the cost to install a sprinkler irrigation system is as follows:

Current Water Use = 0.03 cfs/acre
Amount Conserved
= (0.03 cfs/acre)(0.50) = 0.015 cfs/acre
Income from Sale of Partial Water Rights
= ($17,000/cfs)(0.015 cfs/acre) = $255/acre
Annual Income Increase Due to Yield Increases
= $130/acre
Cost of Irrigation System = $200/acre
Cost of Pumps = $45/acre
Annual O&M = (0.15)($245/acre) = $37/acre/year
Annual Electricity Cost = $7.2/acre/year

Therefore,

		First Year	Annual
Income	=	$385/acre	$130/acre
cost	=	$287/acre	$ 42/acre

RESULTS

Cost

The total cost to BPA is approximately $348,000 assuming the stated water savings. There would be no annual cost to BPA for this alternative.

Implications for Fish

The total flow made available by this alternative cannot be accurately assessed until the public interest for participating is determined. Under the assumed conditions, approximately 20.9 cfs could be conserved from L-6 to the mouth.

Water use reduction is calculated as follows, if 60 percent of the ranchers diverting from L-6 and L-7 participate:

Water Savings from L-7:
= (water right)(% conserved)(% participation)
= (28.0 cfs)(0.50)(0.60)
= 8.4 cfs

Water Savings from L-6:
= (41.8 cfs)(0.50)(0.60)
= 12.5 cfs

Total Water Savings from L-6 to Mouth of Lemhi
= 8.4 + 12.5 = 20.9 cfs

Cost

Costs for this alternative are the same as the Water Withdrawal Reduction alternative.

Cost to BPA

Total Cost to BPA
= (water value/acre)(unit allocation)(water savings)
= ($500/acre)(acre/0.03 cfs)(20.9 cfs)
= $348,300

This includes a unit cost for water of $17,000/cfs. The total acreage required to achieve this water savings if land is purchased directly:

Total Acreage
= (20.9 cfs)(acre/0.03 cfs)
= 697 acres

a roller compacted concrete dam with or without power generation. Table 4.3 shows a comparison of the physical features of each option.

Geologic mapping by the USGS indicates that bedrock at the site consists of metamorphic Precambrian rocks of the Yellowjacket Formation. Rocks of the Yellowjacket Formation vary in lithology throughout the sequence but generally contain medium to dark grey, fine grained feldspathic quartzite. These rocks are exposed in the steep ridges to the northwest and southeast of the site. It is believed that these rocks will provide an adequate foundation for the structure.

The area upstream of the proposed site consists mainly of range and timberland. Water rights on canals with diversions upstream of the dam would have to be provided with water from the reservoir. This can be accomplished either by -routing the irrigation canal around the site or by adding additional outlet works which provide water to the present canal system.

<u>Hydrology</u>

Option 1

The hydrology used to evaluate Option 1 was taken from a report developed in 1982 by the Idaho Department of Water Resources for the Corps of Engineers (IDWR, 1982). The flows used in this analysis were taken from gage records on Challis Creek near Challis and Valley Creek at Stanley. The hydrograph of mean monthly flows is shown on Figure 4.4.

Option 2

Hayden Creek has a drainage of 148 square miles. The mean monthly hydrograph for Hayden Creek at its mouth is shown on Figure 4.5.

ALTERNATIVE 8 - STORAGE

The objective of this alternative is to locate and size a storage reservoir which can augment low flows in the Lemhi. The reservoir would be used to store water during high-flow periods and release it during critical low-flow periods. Water released from the reservior would be used to augment natural flows to provide passage for migrating salmon and steelhead and increase rearing and spawning habitat.

Historically, critical low flows occur during the months of May, July, August, and September. These months correspond with periods of high irrigation demand. Upstream migration of chinook occurs from May through August, usually peaking in June and July. The Lemhi generally reaches its peak stream flow during June snowmelt and rain.

ALTERNATIVE DESCRIPTION

Previous studies analyzing the possibility of placing a storage reservoir in the Lemhi River Valley have been performed by the U.S. Army Corps of Engineers (1985) and the U.S. Bureau of Reclamation (1941 and 1942). These studies, which vary in level of detail, have examined several locations throughout the Valley, including Agency Creek, Bear Valley Creek, and Hayden Creek. Using this information and data gathered through field visits, a suitable site at stream mile 8.1 on Hayden Creek was chosen for the proposed reservoir (Appendix B). The site is immediately downstream of the confluence of Bear Valley Creek at the narrowest point in the Hayden Creek Valley.

Two storage options on Hayden Creek are addressed in this report. The first is the project under study by the Corps of Engineers, a 29,000 acre-foot impoundment. The second is a 17,200 acre-foot impoundment evaluated as part of this task. Both options include

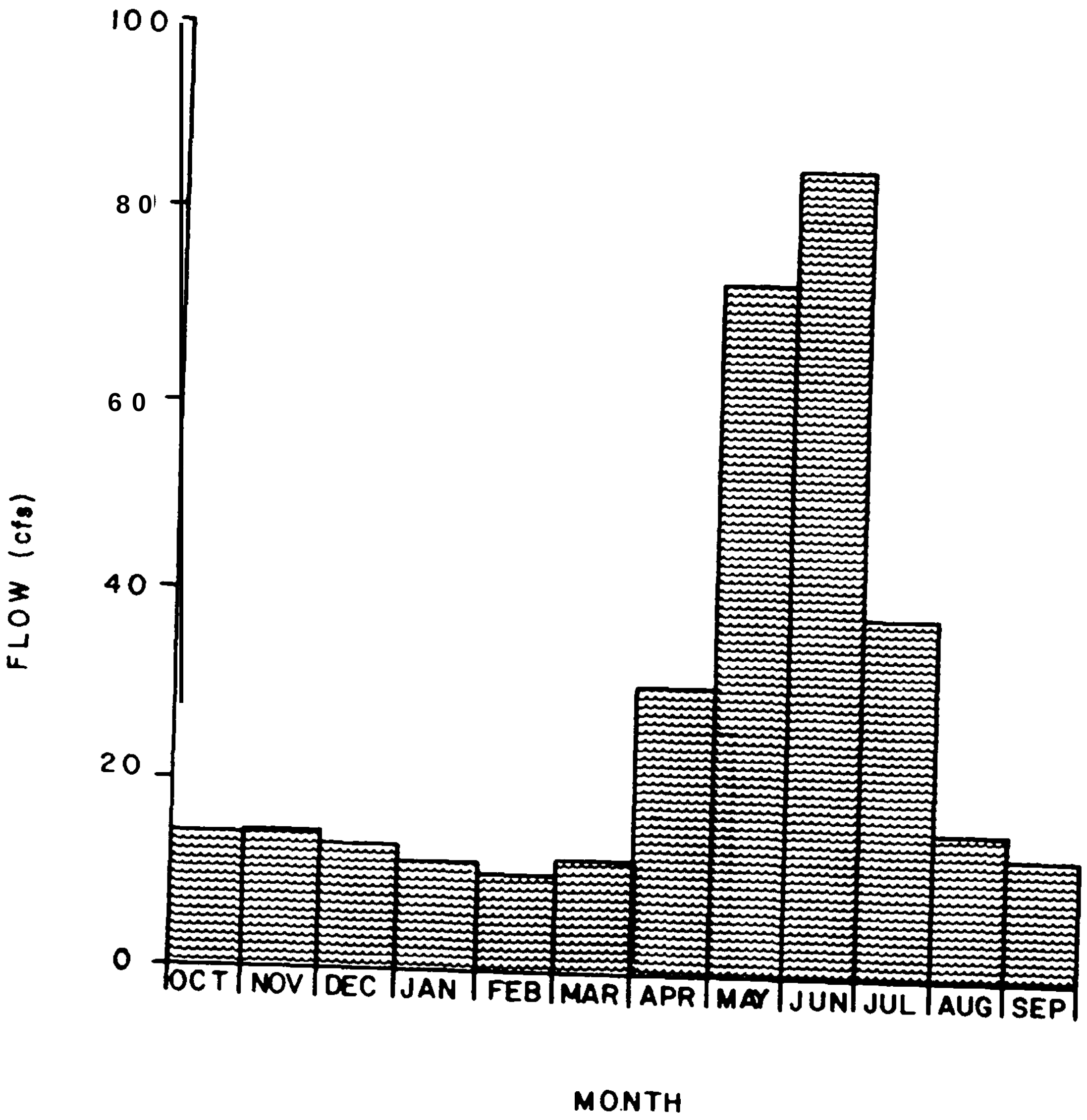


FIGURE 4.4

LEMHI RIVER
HABITAT IMPROVEMENT STUDY
MEAN MONTHLY FLOWS
AT DAM SITE, OPTION I

DATE: NOVEMBER 1985
JOB NUMBER: SI028.03

OTT

TABLE 4.3

PHYSICAL FEATURES OF STORAGE OPTIONS

	Option 1 (CORPS)	Option 2 (OTT)
Total Storage	29,000 acre-feet	17,200 acre-feet
Active Storage	25,500 acre-feet	15,000 acre-feet
Dead Storage	3,500 acre-feet	2,200 acre-feet
Spillway Elevation	6,180 feet	6,140 feet
Dead Storage Elevation	6,040 feet	6,010 feet
Maximum Dam Height	300 feet	260 feet
Approx. Crest Length	1,300 feet	1,150 feet
Crest Width	30 feet	30 feet
Spillway Capacity	27,600 cfs	27,600 cfs

This hydrograph was derived from the USGS gage on Lemhi River near Lemhi and then correlated with three years of Hayden Creek data gathered by the Bureau of Reclamation in the early 1940s. At the proposed dam site, Hayden Creek drains 80 square miles of area. A synthetic hydrograph has been developed using the ratio of the drainage areas and mean monthly flows for Hayden Creek at the mouth. This assumes that all other hydrologic factors are constant over the drainage area. Figure 4.6 shows the mean monthly flows in Hayden Creek at the site.

Operation

Option 1

In the reservoir analysis performed by the IDWR (19821, synthesized monthly flows from 1922 through 1971 were used. The percentage of flows available for storage were assumed to be 100 percent for October through April, 50 percent for May, and 0 percent for June through September. A minimum instream flow of 6 cfs also was assumed. The required augmentation flows were computed from the Lemhi River gage records adjusted to the critical reach at the 28 Club Restaurant near diversion L-7. These flows were subtracted from minimum required flows to derive the required supplemental flows. The required minimum flows estimated by the U.S. Fish and Wildlife Service were as follows:

October to March:	Natural Flows
April 1 to May 15:	150 cfs
May 15 to September 30:	75 cfs

Option 2

Most of the water rights on Hayden Creek are diverted from approximately April 1 to October 1 each year. The allocated water rights between the proposed dam site and.the mouth of Hayden Creek

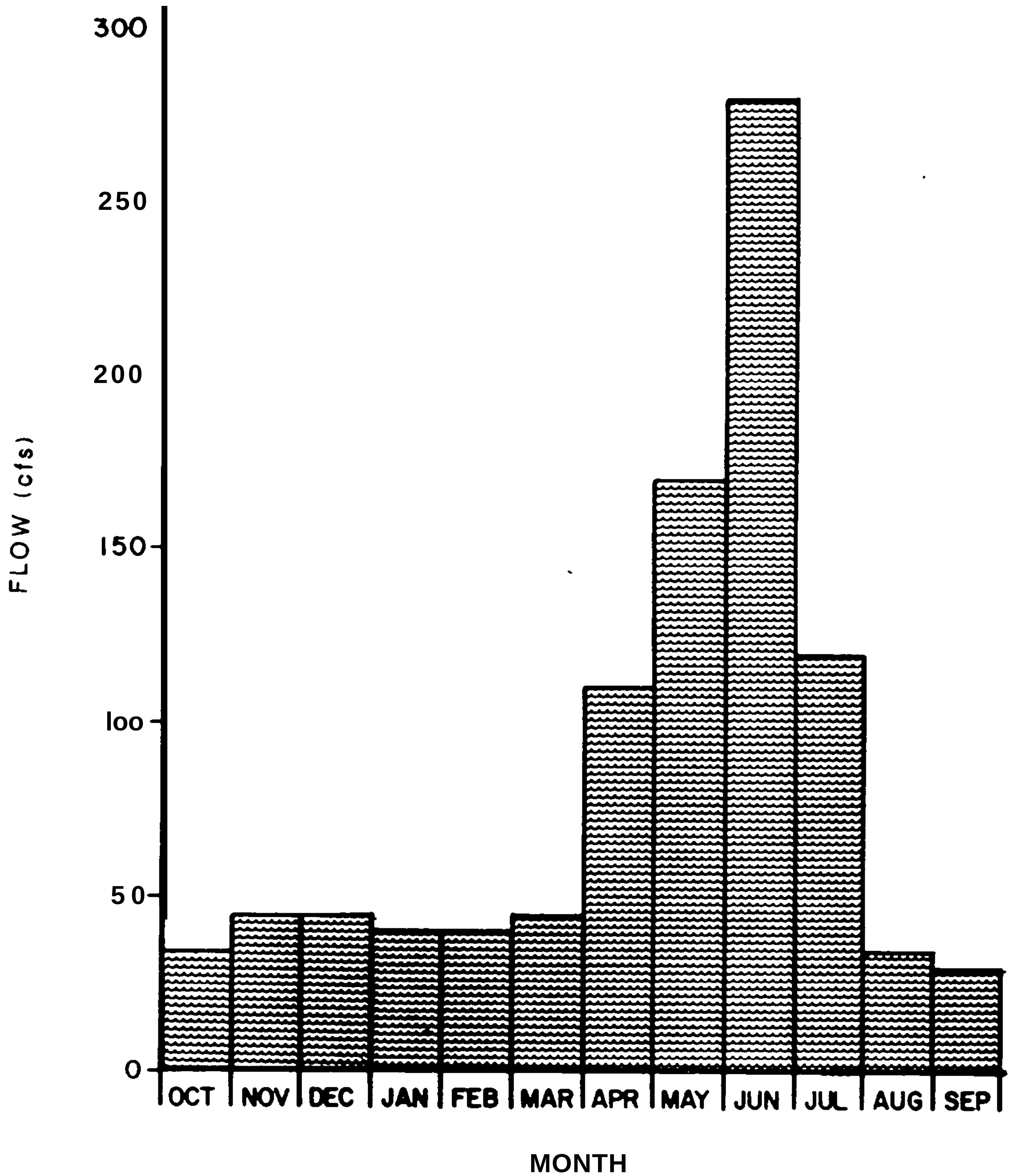


FIGURE 4.5

LEMHI RIVER
HABITAT IMPROVEMENT STUDY

MEAN MONTHLY FLOWS IN
HAYDEN CREEK AT MOUTH

DATE: NOVEMBER 1985
JOB NUMBER: S1028.03

OTT

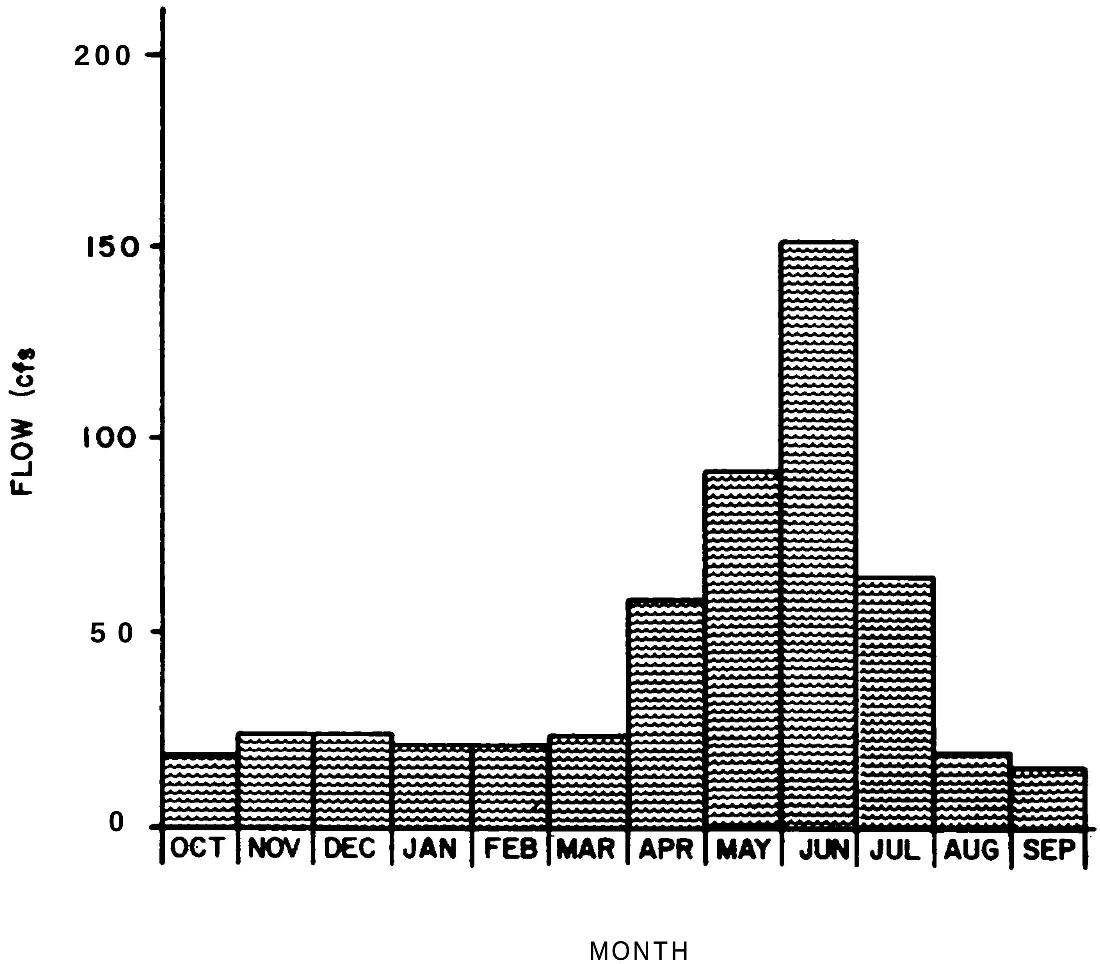
total approximately 63 cfs. Basin Creek, Rye Grass Creek, and Meadow Creek all supplement flows in Hayden Creek below the proposed site. These streams provide ample flow for water rights allocated downstream of Meadow Creek. However, approximately 35 cfs has been allocated at points between the proposed site and Meadow Creek and must be released from the dam.

A flow of 10 cfs would be released during reservoir recharging periods to satisfy domestic and livestock uses and to provide an aesthetic flow. These periods extend from November through March when water rights are not exercised. Aesthetic flows may vary during actual operation depending on the contribution by groundwater and Meadow Creek, which is 2.5 miles downstream.

The reservoir would release sufficient flow to provide passage for upstream migrants. Minimum instream flows and preferred augmentation flows have been computed for several critical points on the Lemhi, and are given in Table 3.1. Diversion L-6, at RM 7.40, is historically the most critical point with respect to passage on the River. OTT estimated that 50 cfs must be added to the Lemhi from the reservoir in order to provide for passage and to increase habitat. It is assumed that water released from the reservoir would not be diverted before reaching L-6.

In most years, critical flows can be maintained without augmentation. In these years, the dam would release flows according to an operating procedure that would provide an increase in rearing habitat. For this Study, it was assumed that 50 cfs would be released during the months of May, July, August, and September.

Modified average monthly flows in Hayden Creek below the site of the proposed dam can be seen on Figure 4.7. This figure shows base flows that remain in the stream, flows reguired for storage, and flows to be released for augmentation. Average monthly flows



AREA RATIO = 0.541
DRAINAGE AREA AT DAM SITE VS.
DRAINAGE AREA OF 'HAYDEN CREEK
AT MOUTH

FIGURE 4.6

LEMHI RIVER
HABITAT IMPROVEMENT STUDY

MEAN MONTHLY FLOWS
AT DAM SITE, OPTION 2

DATE: NOVEMBER 1985
JOB NUMBER: S1028.03

OTT

during October are less than those allocated through water rights legislation, and cannot be used for storage. It can also be seen on Figure 4.7 that the month of June accounts for a great deal of the total yearly storage requirements. Actual June flows will affect the amount of water available for augmentation during July, August, and September.

Area-capacity curves have been developed using 1 to 62,500 scale topographic maps with 80-foot contour intervals (Figure 4.8). The maximum capacity of the reservoir is 17,200 acre-feet. The minimum volume of active storage, calculated using mean monthly flows, is 15,000 acre-feet. The remaining 2,200 acre-feet is dead storage.

Dam

For the development of cost estimates, a 260-foot high, roller compacted concrete dam was assumed. An 80-foot gated spillway and outlet works are included. Maximum pool elevation in the reservoir is 6,140 feet and the crest length of the dam is 1,150 feet and its width is 30 feet. The downstream face is sloped 0.8H:l.0V, and the upstream face is vertical

Power

Preliminary analyses have also been performed for the storage reservoir with the addition of hydropower. Included in this alternative are outlet works, powerhouse, transmission line, and appurtenant electrical and mechanical equipment. The powerhouse would contain two 1,150 kw Francis turbines. Each unit would have a design flow of 70 cfs and a design head of 200 feet. Power veneration will commence April 1 and extend through September 30. igure 4.9 shows the average monthly pool elevation and gross head ased on an estimated streambed elevation of 5,980 feet. It was assumed that all water released from the dam would be used for

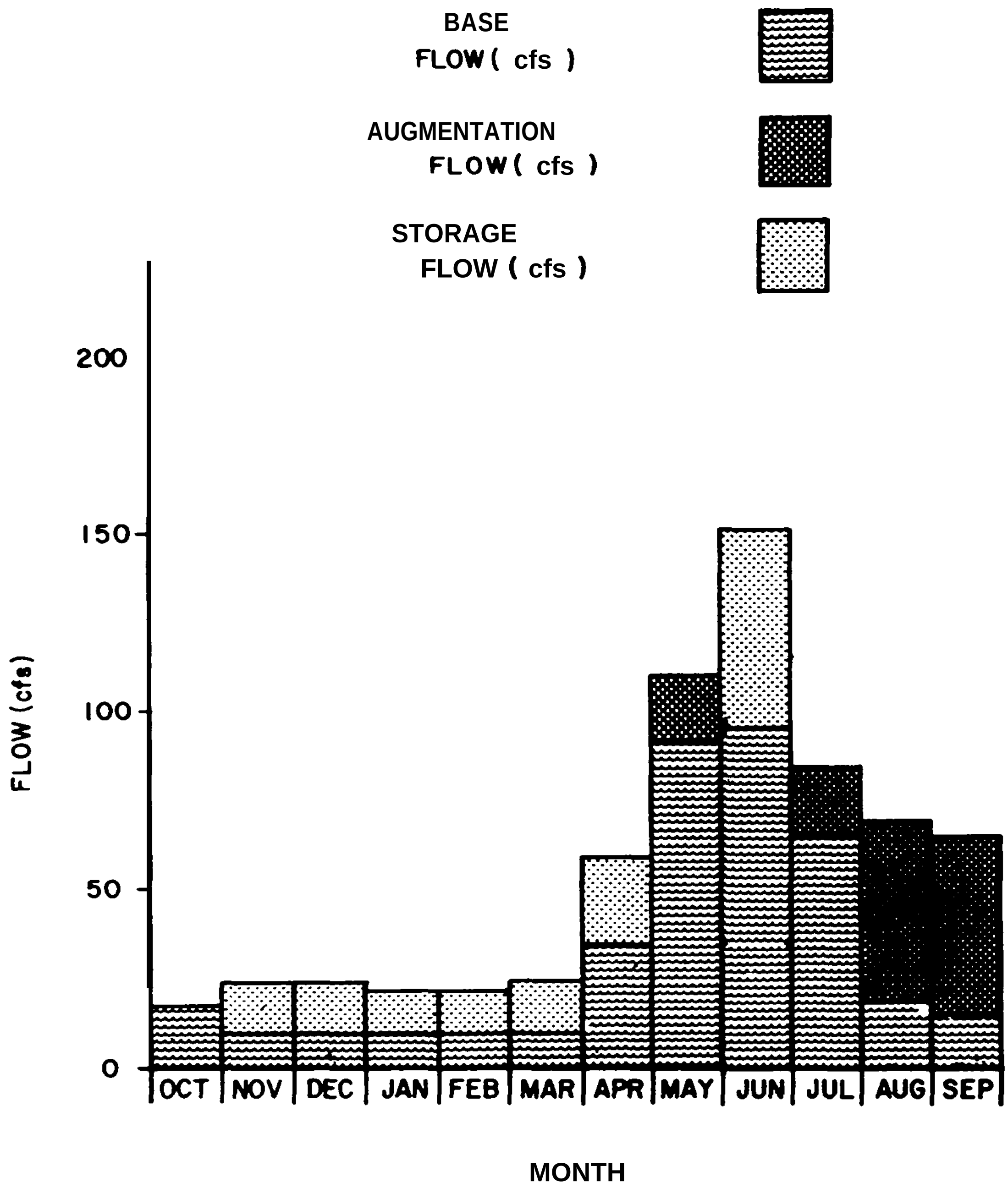
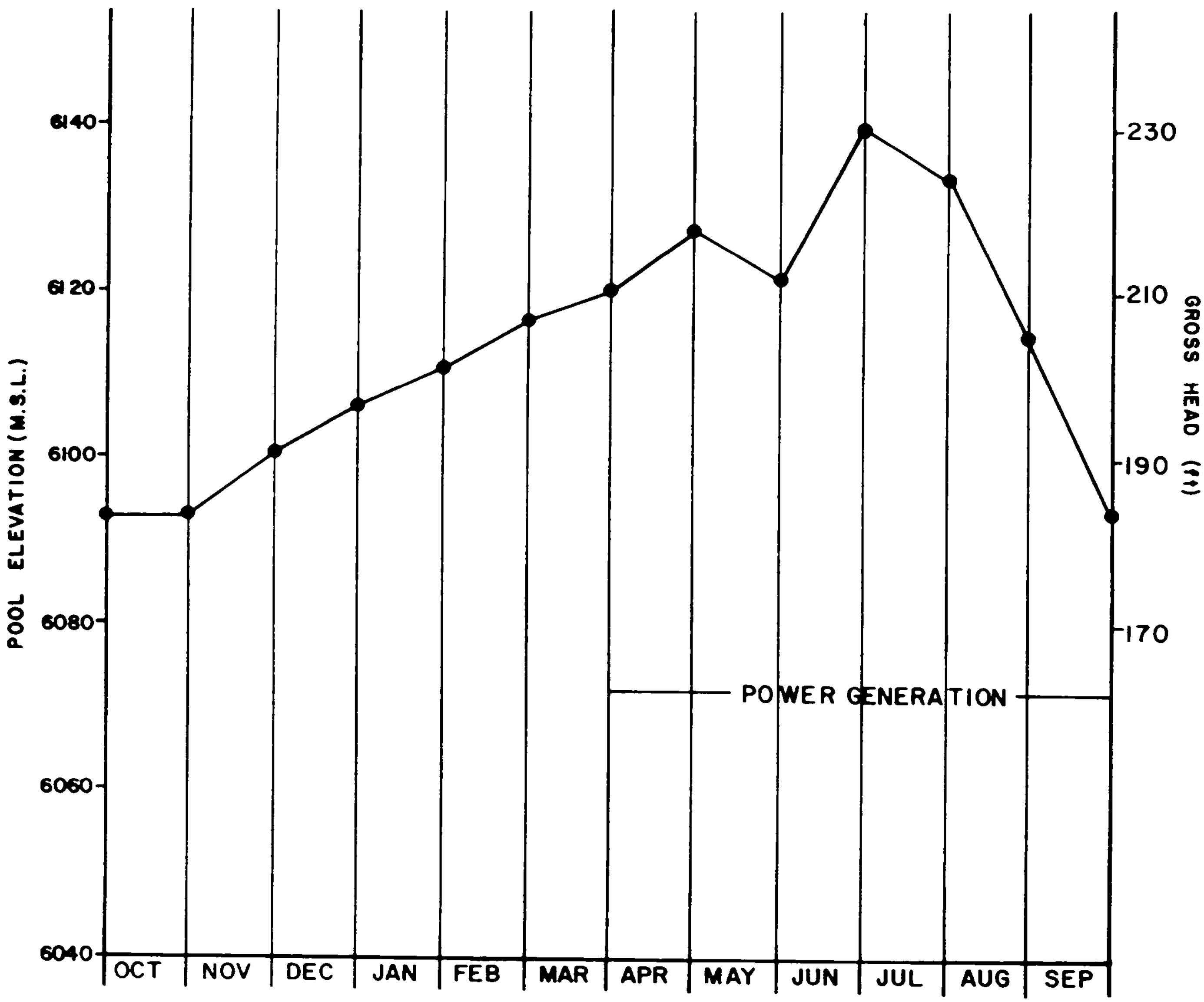


FIGURE 4.7

LEMHI RIVER
HABITAT IMPROVEMENT STUDY

MODIFIED FLOWS IN HAYDEN
CREEK AT DAM SITE, OPTION 2

DATE: NOVEMBER 1985
JOB NUMBER: S1028.03



* ASSUMED DOWNSTREAM WATER SURFACE ELEVATION @ 5910

FIGURE 4.9

LEMHI RIVER
HABITAT IMPROVEMENT STUDY
MONTHLY POOL ELEVATION AND GROSS HEAD

DATE: NOVEMBER 1985
JOB NUMBER: S 1028.03

OTT

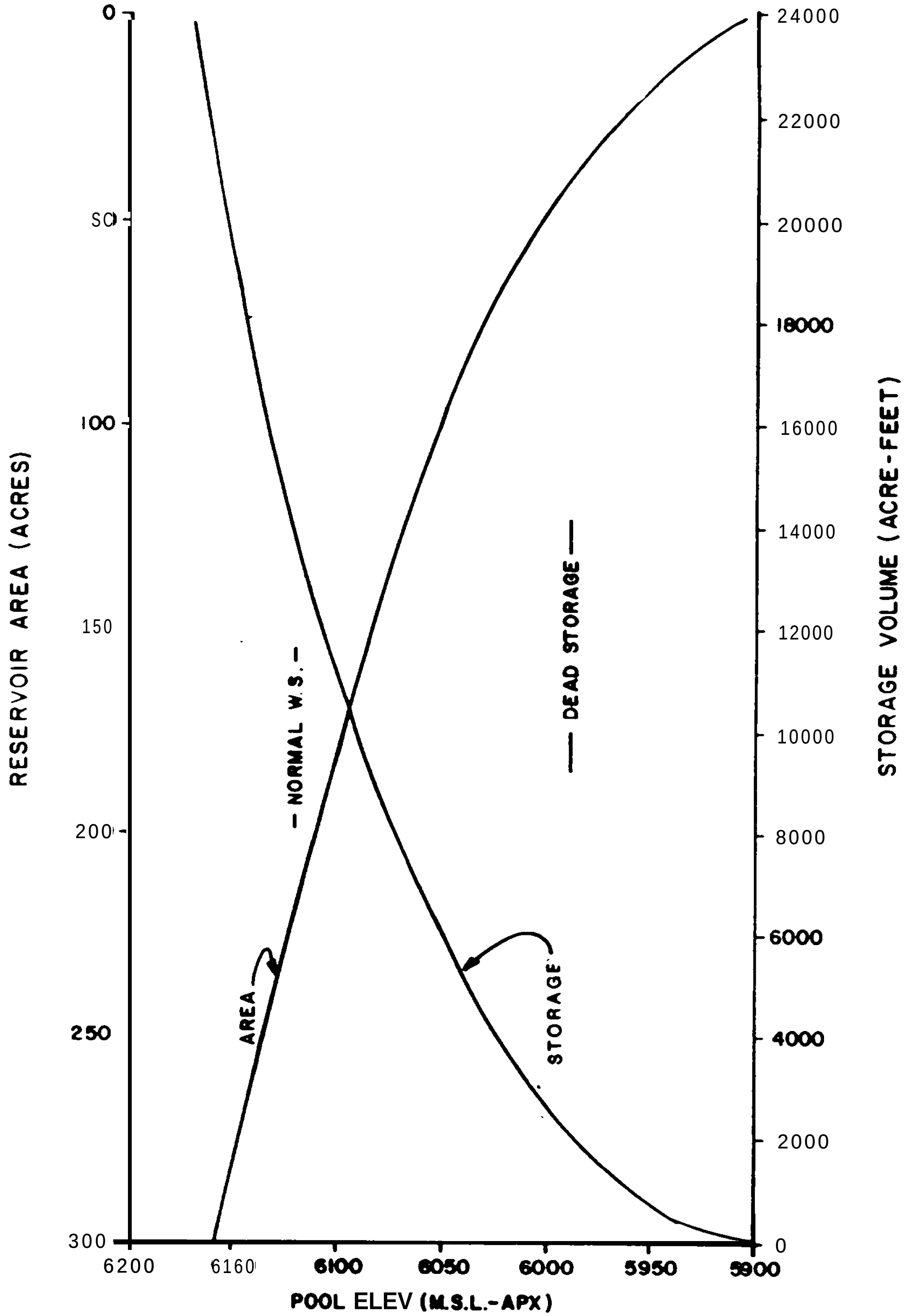


FIGURE 4.8

LEMHI RIVER
HABITAT IMPROVEMENT STUDY

AREA-CAPACITY CURVES

DATE: NOVEMBER 1985
J08: NUMBER S1028.03

OTT

TABLE 4.4

CAPITAL COSTS FOR STORAGE RESERVOIR WITH POWER

ITEM	UNIT	QUANTITY	UNIT COST	TOTAL COST
LAND	AC	225	$ 400.	$ 90,000
RESERVOIR CLEAR & GRUB	AC	225	220.	50,000
DAM SPILLWAY & OUTLET WKS	LS	-a-	---	21.100.000
POWER PLANT				1,420,000
Turbines & Generator	LS	---	---	837,000
Accessory Elec. Equip.	LS	---	---	583,000
SWITCHYARD	LS	---	---	68,000
TRANSMISSION LINE				755,000
New Line	MI	8.1	45,000.	365,000
Upgrade	MI	26.0	15,000.	390,000
ADDITIONAL OUTLET WKS FOR POWER	LS	we-	---	150,000
POWERHOUSE	SQ FT	975	150	146,000
BUILDINGS, GROUNDS, & UTILITES	LS	---	---	240,000
ROADS				61,000
Paved	FT	2500	10.	25,000
Gravel	FT	6000	6.	36,000
CIVIL SITE WORK	LS	---	---	30,000
MOBILIZATION	LS	---	---	800,000
SUBTOTAL				24,910,000
20% ENGINEERING & ADMINISTRATION				4,980,000
15% COMPOSITE CONTINGENCY				3,740,000
TOTAL CONSTRUCTION				$33,630,000
INTEREST DURING CONSTRUCTION				5,200,000
TOTAL CAPITAL INVESTMENT				$38,830,000

power production. The expected average annual energy production of the plant would be 5,060 MWh.

Costs

Several sources were used to develop cost summaries in the following section. Unit costs developed in this Study have been used wherever possible. Data on roller compacted concrete (RCC) dams were obtained from the Corps of Engineers. Cost estimates were derived using volume ratios of similar structures. Power-plant costs were derived from cost curves developed by OTT and the Corps of Engineers for the Northwest Power Planning Council's PNW Hydropower Data Base. These curves estimate component costs based on installed capacity and other physical characteristics of the project.

RESULTS

Costs

Preliminary cost estimates have been prepared for both reservoirs with power and the OTT alternative without power (Tables 4.4 and 4.5, respectively). Total investment represents total capital costs plus 20 percent for engineering and administration, and a 15 percent contingency. Total investment does not include any annual or replacement costs. Operation and maintenance costs are given separately. Prices shown have been escalated to 1985 price levels. The costs for both options are summarized in Table 4.6.

Implications for Fish

Benefits from the construction of a storage reservoir on Hayden Creek would be derived in four areas: flow augmentation, power generation, flood control, and recreation. Discharges from the reservoir would provide the necessary flows in the Lemhi to allow fish passage at critical points during low-flow periods. Flow

TABLE 4.6

COSTS FOR STORAGE RESERVOIR OPTIONS

	First Cost ($1,000)	O&M ($1,000)
Option 1 with 1155 kW Power Plant	42,500	162
Option 2 with Power	38,830	160
Option 2 without Power	34,881	40

TABLE 4.5

CAPITAL COSTS FOR STORAGE RESERVOIR WITHOUT POWER

ITEM	UNIT	QUANTITY	UNIT COST	TOTAL COST
RESERVOIR CLEAR & GRUB	AC	225	$ 400.	$ 90,000
DAM SPILLWAY & OUTLET WKS	LS	---	---	21,100,000
BUILDINGS, GROUND & UTILITIES				213,000
ROADS				61,000
Paved	FT	2500	10.	25,000
Gravel	FT	6000	6.	36,000
CIVIL SITE WORK	LS	---	---	30,000
MOBILIZATION	LS	---	---	670,000
SUBTOTAL				22,134,000
20% ENGINEERING & ADMINISTRATION				4,427,000
15% COMPOSITE CONTINGENCY				3,320,000
TOTAL CONSTRUCTION				$29,881,000
INTEREST DURING CONSTRUCTION				5,000,000
TOTAL CAPITAL INVESTMENT				$34,881,000

augmentation also would increase rearing and spawning habitat. A summary of flow modifications for the Option 2 storage reservoir site is shown in Table 4.7. An average annual energy of about 5,060 MWh would be produced if the "with-power" alternative is adopted. This power would be sold to local utilities.

Flood control benefits might be realized by residents of lower Hayden Creek. Typical flooding occurs when spring rains accompany snowmelt in the month of June. Recreation benefits such as fishing and boating might be realized from the reservoir. Only the potential benefits of power have been calculated here. The average annual augmented flows on Figure 4.7 can be used to calculate the fisheries benefit in other tasks. A summary of augmented flows and power benefits is presented in Table 4.8. The power benefits assume a $.O5/kWh cost for power.

Other Considerations

In addition to economic and flow benefits, there are several considerations that have a bearing on alternative selection.

Augmented flows released from the reservoir could be diverted for irrigation before reaching the critical reach about 31 miles below the reservoir. The water right associated with the reservoir could be superceded by the prior irrigation rights on Hayden Creek and the Lemhi River. There would have to be a procedure by which the irrigation diversions would be monitored to ensure that augmented flows are not being diverted unnecessarily.

An alternative involving a large dam would be difficult to implement, and it would not be completed until approximately 1992. Public sentiment is generally against large dam projects, although the Lemhi Valley irrigators have said they would support such a project because there would be more water available for irrigation during low flows.

TABLE 4.7

FLOW MODIFICATION AT LOCATION OF PROPOSED STORAGE RESERVOIR

MONTH	MEAN INFLOW cfs	WATER RIGHT CfS*	AESTHETIC FLOW cfs	AUGMENTATION FLOW cfs	MEAN OUTFLOW cfs
October	18	35	0	0	18
November	24	0	10	0	10
December	24	0	10	0	10
January	22	0	10	0	10
February	22	0	10	0	10
March	24	0	10	0	10
April	59	35	0	0	35
May	92	35	0	20	112
June	151	35	0	0	95
July	65	35	0	20	85
August	19	35	0	50	69
September	16	35	0	50	66

l Water rights flows represent allocations between the site and Meadow Creek.

TABLE 4.8

AUGMENTATION FLOWS AND POWER BENEFITS

AUGMENTATION BENEFIT:

Month	Option 1	Option 2
October	-5.2 cfs	-0-
November	-7.9 cfs	-14 cfs
December	-6.8 cfs	-14 cfs
January	-5.6 cfs	-12 cfs
February	-5.0 cfs	-12 cfs
March	-6.0 cfs	-14 cfs
April	-15.2 cfs	-24 cfs
May	-27.8 cfs	+20 cfs
June	+6.0 cfs	-56 cfs
July	+19.5 cfs	+20 cfs
August	+34.8 cfs	+50 cfs
September	+15.8 cfs	+50 cfs

POWER BENEFIT:

Average Annual Energy	$136,500	$253,000

ALTERNATIVE 9 - TRAP AND HAUL

The objective of this task is to develop a trap and haul system that will trap upstream and downstream migrating salmon and steelhead and transport them around critical low-flow reaches of the Lemhi. The system includes a juvenile trap located above the critical reaches and an adult trap located near the mouth of the Lemhi.

Other enhancement alternatives presented involve methods to increase the amount of flow in the stream and thereby aid fish in their migration. This alternative does not attempt to solve the problem of low flow in the lower reaches of the Lemhi. Rather, it provides a method of circumventing the critical reach during low-flow events, thereby improving upstream and downstream passage.

ALTERNATIVE DESCRIPTION

Juvenile Facility

The site selected for a juvenile trap and haul facility is located at RM 30.4, between diversions L-41 and L-42, immediately upstream from the confluence of Hayden Creek. The location is shown on Figure 8.3, Appendix B. State Highway 28 runs adjacent to the left bank of the River providing easy access for construction and transportation of fish. Access to the riqht bank for construction and maintenance would require crossing the River at Lemhi and traveling approximately 1.5 miles on unimproved roads to the site.

Substantial improvements, including some sections of new road would be required for adequate passage along the right bank. A woodframe bridge exists approximately 0.3 miles upstream which would provide closer access for foot traffic, but without extensive structural work it is thought to be unsafe for heavy equipment.

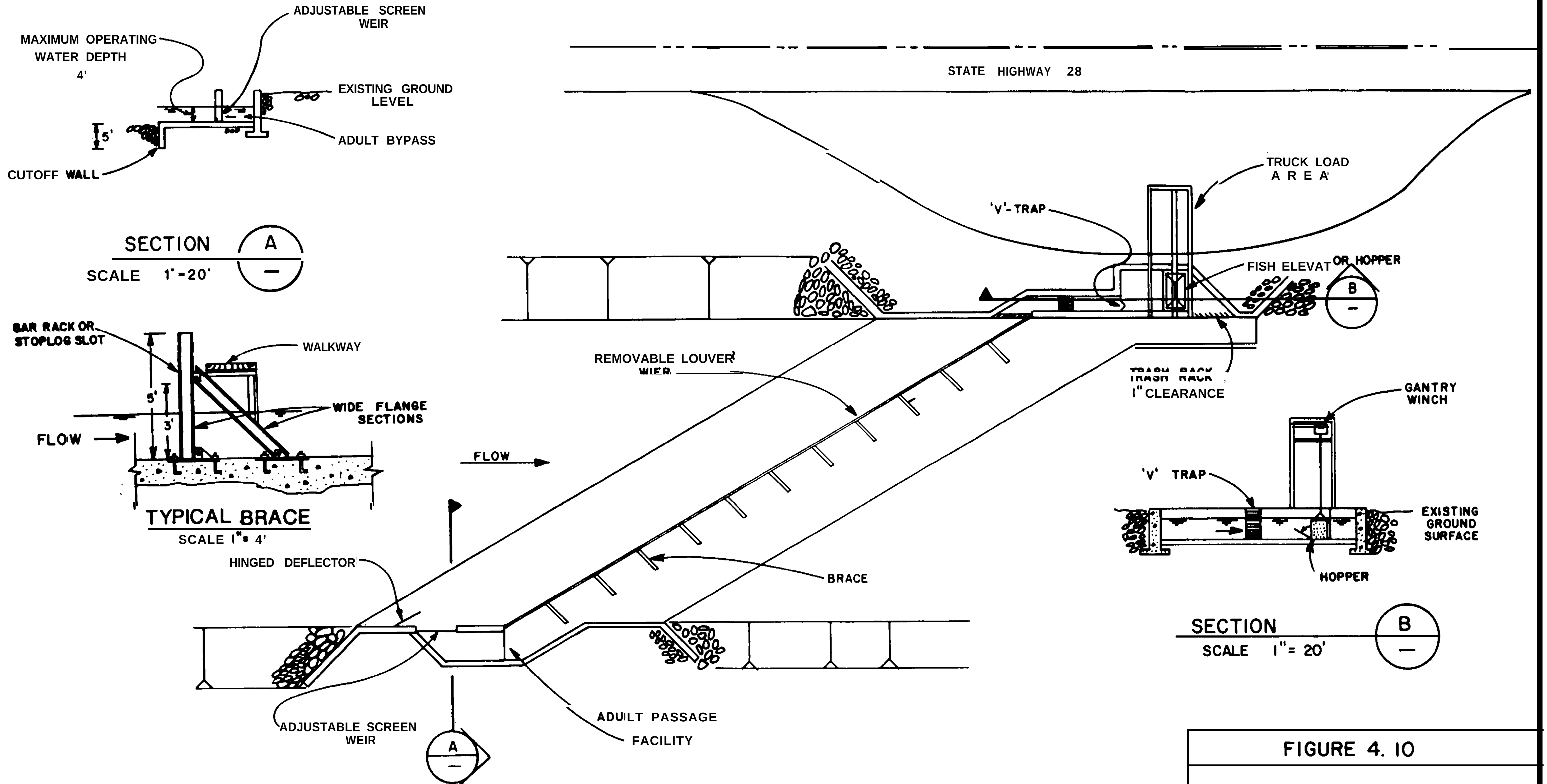
The stream channel at this point is approximately 60 feet wide. Alluvium at the site is cobble to boulder size, due to the relatively steep gradient of the River. Bank material is composed of silts to coarse sands and gravels, typical of most of the Lemhi Valley.

The juvenile trap facility consists of a permanent concrete slab, louver fish barrier, juvenile fish trap, and an adult fish bypass. Details are shown on Figure 4.10. The slab is 30 feet wide and extends bank-to-bank. To prevent accumulation of bedload, the slab is sloped slightly downstream. The slab also would aid in reducing turbulence around the louver system. Cutoff walls would extend 3 feet into the alluvium on the upstream edge and 5 feet on the downstream edge of the slab to prevent scour during peak runoff.

A louver fish barrier 120 feet long is oriented 30 degrees to the direction of flow. The barrier consists of 12 separate panels, each 10 feet in length. Panels would contain interchangeable aluminum vanes with a 2-inch clear space between vanes.

Louver panels slide into steel braces at the joint. Braces are pinned to permanent brackets inset in the concrete slab. Louver panels are equipped with automatic pressure-release mechanisms. These would allow the panels to lay down during sudden flow surges or debris accumulation.

A juvenile fish bypass is placed at the downstream end of the louver system on the left bank. Fish move down the bypass channel and through a 'V' trap into a holding pool. A vertical aluminum punched plate crowds fish into a mechanical elevator at the end of the pool. The elevator consists of a 4-foot by 4-foot by 6-foot



PLAN

SCALE 1"= 20'

FIGURE 4. 10

LEMHI RIVER
HABITAT IMPROVEMENT STUDY

JUVENILE TRAP AND HAUL FACILITY

DATE: NOVEMBER 1985

JOB NUMBER: S1028.03

OTT

perforated steel hopper. The upstream wall of the hopper is hinged, allowing it to lay flat while fish enter. When the hopper is full the wall will close. The hopper is hoisted by means of a gantry winch, and then moved to the truck loading area. Fish are loaded directly into a truck through a gate in the bottom of the hopper.

Since the upstream migration period for adult steelhead coincides with the period of operation of the juvenile fish trap, an adult fish bypass is provided. Adult fish are guided upstream along the louver barrier to a fishway entrance. The fishway consists of a 6-foot wide concrete channel at the right abutment of the louver barrier. Upstream migrants would pass through the fishway channel, over an adjustable screen weir, and back into the River above the louver barrier. The adjustable screen weir could be a telescoping fish screen, float-adjusted to remain 6 inches below the water surface. The screen would allow water to pass through the fishway while preventing most downstream migrants from passing the louver barrier. A trash deflector, placed upstream of the fishway exit, also would aid in diverting juveniles from the fishway.

<u>Adult Faciltiy</u>

The site chosen for the adult trap and haul facility is approximately 100 yards upstream from the mouth of the Lemhi and downstream of diversion L-l. The location is shown on Figure B.1, Appendix B. At this point, the river channel tends to the right bank due to a bend in the River. Material on the right and left banks consists of alluvial deposits, mostly sands and gravels. The streambed is composed of cobble to boulder size alluvium.

The adult trap includes a concrete slab, removable barrier, holding pool, and elevator. Details are shown on Figure 4.11. To maintain a constant cross section, a concrete slab would be

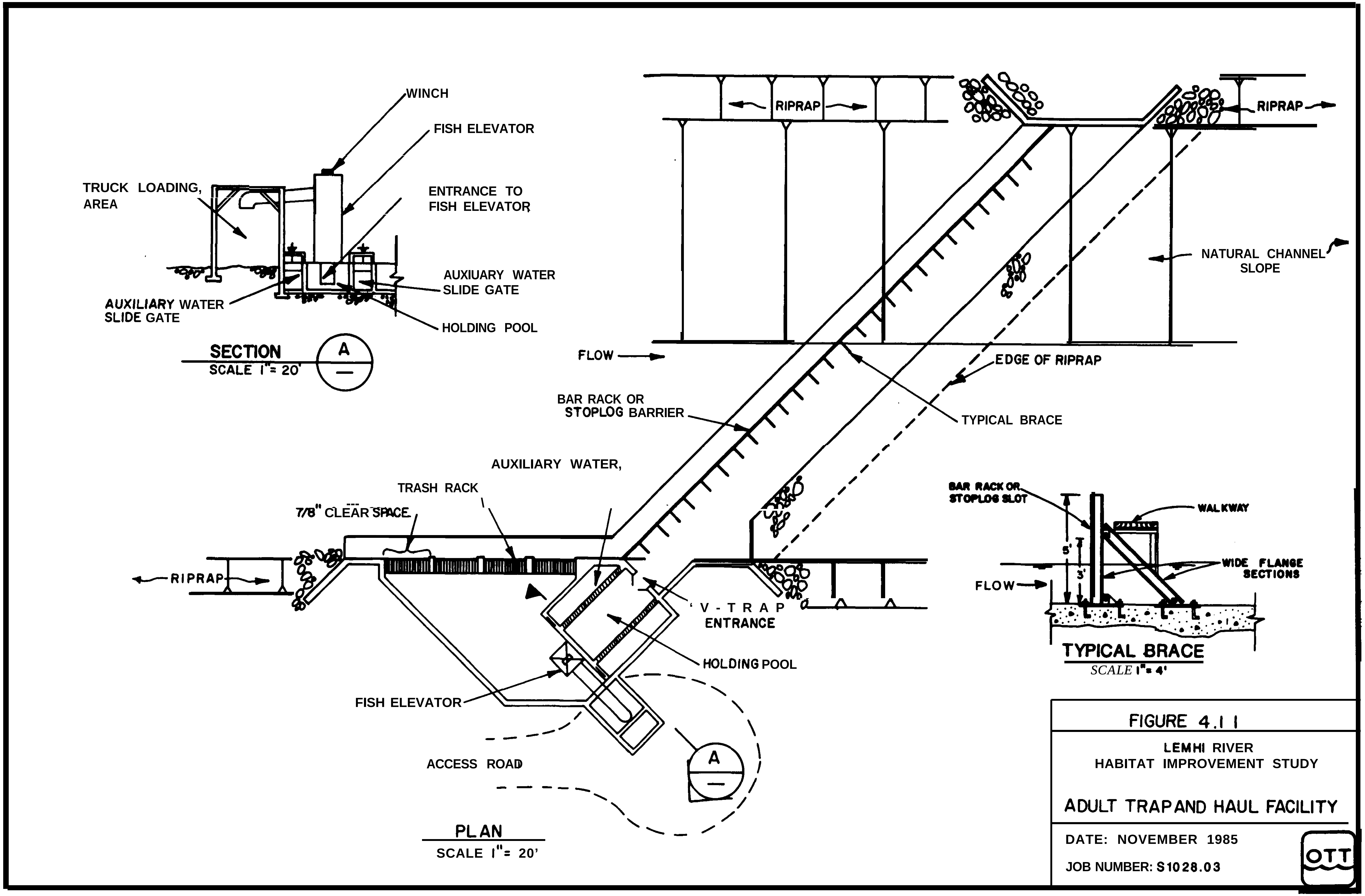


FIGURE 4.11

LEMHI RIVER
HABITAT IMPROVEMENT STUDY

ADULT TRAP AND HAUL FACILITY

DATE: NOVEMBER 1985

JOB NUMBER: S1028.03

OTT

installed and would extend 100 feet across the River. From the right bank it would run horizontally 50 feet and then change to a 10 percent slope up to the left bank training wall. This configuration is designed to approximate the natural shape of the River channel at this site. Cutoff walls would be placed at the upstream and downstream edges of the slab, and extend 5 feet into the alluvium. Cutoff walls are necessary to prevent scour during high flows.

A removable bar rack and stoplog fish barrier would be attached to the slab at a 45-degree angle to the direction of flow. The bar rack panels are constructed from aluminum pipe placed with a one-inch clear space between bars. Panels 4 feet high by 5 feet long are placed vertically in steel braces, similar to those used at the juvenile trap facility. Stoplogs are used to regulate and concentrate the flow during extreme low-flow periods. To maintain the flow near the fish trap entrance, stoplogs would be added from the bank.

Adult fish would move upstream along the barrier to the right bank and enter a fish trap. Auxiliary water is diffused into both sides of the lo-foot wide and 20-foot long holding pool. Auxiliary water would pass from the River through the trashracks and into the holding pool. Stoplogs would be added to the barrier if additional flow is needed. Fish in the holding pool would be crowded into the elevator with a vertical aluminum punched plate. Water pumped into the elevator would then raise the fish to the elevation of the loading chute. Once loaded into the tank truck, fish could be hauled to the upper watershed.

OPERATION

Juvenile Facility

The juvenile trap is designed to operate annually during the downstream migration period, typically from March 1 to June 1.

Removal of the barrier is dictated by the end of the downstream migration or by high flows from spring runoff during May or early . June.

The louver barrier would accommodate a maximum flow of 450 cfs while maintaining an approach velocity of less than 1 fps. This flow is exceeded less than twenty percent of the time during the month of May. Way is typically the highest flow month of the downstream migration period. When flows rise above 450 cfs the louver barrier would be removed.

Adult Facility

The adult trap would be operated only on an emergency low-flow basis. Upstream migration of adult steelhead and chinook spans a period from March through August. During this period, the barrier dam would be installed only when the combination of available flow in the River and irrigation demands cause an upstream passage . barrier. This would occur approximately one in four years. The average duration of operation is estimated to be one month.

RESULTS

Cost

Cost estimates have been prepared separately for each site. Total project costs include estimates for capital and annual costs. Capital costs include construction, engineering services, and equipment. Annual costs include labor and materials required for operation of facilities and trucks. Detailed cost summaries are given in Tables 4.9 and 4.10.

Implications for Fish

The objective of this task is to provide a means by which fish can pass critical reaches of the River. Benefits of this alternative

TABLE 4.9

CAPITAL AND ANNUAL COSTS FOR THE JUVENILE
TRAP AND HAUL FACILITY

ITEM	UNIT	QUANTITY	UNIT COST $/UNIT	TOTAL COST $
MOBILIZATION	LS			$ 10,000
DEWATERING	LS			5,000
EARTHWORK				12,900
Excavation (trench)	CY	1500	3.00	4,500
Backfill (common)	CY	1000	1.00	1,000
Riprap (Material Placement)	CY	210	35.00	7,400
CONCRETE				107,500
Structural	CY	200	350.00	70,000
Slab	CY	150	250.00	37,500
METALS				49,400
Structural Fabricated	LB	8000	2.00	16,000
Bracing	LB	4000	2.00	8,000
Louvers	LB	2600	9.00	23,400
Fence	LS			2,000
WOODS				1,000
Stoplogs	Ls			1,000
EQUIPMENT				90,000
Winch				10,000
Truck				80,000
MISCELLANEOUS				12,000
Access Road	LS	-		10,000
Civil Site Work	Ls	-		2,000

TABLE 4.9

(Continued)

CAPITAL AND ANNUAL COSTS FOR THE JUVENILE
TRAP AND HAUL FACILITY

ITEM	UNIT	QUANTITY	UNIT COST $/UNIT	TOTAL COST $
Subtotal				287,800
20% Engineering and Admin.				57,600
30% Contingency				86,300
TOTAL CAPITAL COST				$431,700

ANNUAL COST	
Labor (145 man-days @ $128/man-day)	18,600
Material	500
Truck Maintenance	2,300
TOTAL ANNUAL COST	$ 21,400

TABLE 4.10

CAPITAL AND ANNUAL COSTS FOR THE ADULT TRAP AND HAUL FACILITY

ITEM	UNIT	QUANTITY	UNIT COST $/UNIT	TOTAL COST $
MOBILIZATION	LS	-		$10,000
DEWATERING	LS			5,000
EARTHWORK				16,800
Excavation (trench)	CY	2200	3.00	6,600
Backfill (common)	CY	1400	1.00	1,400
Riprap (Material Placement)	CY	250	35.00	8,800
CONCRETE				75,400
Structural	CY	94	350.00	32,900
Slab	CY	170	250.00	42,500
METALS				70,000
Structural Fabricated	LB	10,000	2.00	20,000
Trash & Diffusion Racks	LB	7,800	2.00	15,600
Bracing	LB	4,200	2.00	8,400
Gates	LS	2	4,000.00	8,000
Aluminum Bar Rack	LB	2,000	9.00	18,000
WOODS				500
Stoplogs	BF	1,200	0.35	500
EQUIPWENT				110,000
Winch	LS	2		10,000
Pump	LS	2		20,000
Truck	LS	1		80,000
MISCELLANEOUS				7,000
Access Road	LS	-		5,000
Civil Site Work	LS			2,000

TABLE 4.10

(Continued)

CAPITAL AND ANNUAL COSTS FOR THE ADULT TRAP AND HAUL FACILITY

ITEM	UNIT	QUANTITY	UNIT COST S/UNIT	TOTAL COST $
Subtotal				294,700
20% Engineering and Admin.				58,900
30% Contingency				88,400
TOTAL CAPITAL COST				$442,000
ANNUAL COST				
Labor (132 man-days @ $128/man-day)				4,100
Material				100
Truck Maintenance				200
TOTAL ANNUAL COST				$ 4,400

accrue solely from an increase in fish production. A trapping efficiency of approximately 81 percent (90 percent capture and 90 percent transportaion efficiencies) is assumed for the juvenile fish trap. The adult fish trap is assumed to be 90 percent efficient.

CHAPTER5

BENEFITS ANALYSIS

SELECTION OF OPTIONS

At the interagency meeting of September 11, 1985, each of the nine alternative solutions assessed in OTT's Draft Evaluation of Alternatives Report (Chapter 4) were discussed. The following conclusions were reached by agency personnel regarding OTT's emphasis for the remainder of the Study:

- The most important item to be addressed in the benefits analysis is the improvement of upstream migration conditions for salmon and steelhead.

- Increased juvenile rearing habitat in the lower Lemhi River might be created if stream flow is seasonally augmented, but greater benefits will probably be realized if adult upstream passage is improved.

- Downstream juvenile migration enhancement, through improved fish screens and bypasses, is not an integral part of the Study and need not be addressed as a primary assessment objective. Currently, NHFS funds and IDPG implements a program for upgrading and maintaining irrigation diversion screening facilities.

Based upon these conclusions, it was decided that the following five actions should be assessed in the benefits analysis:

- Diversion Dams. The problem of fish spawning migration blockage is most severe at diversions L-5, L-6, and L-7. However, all diversion dams listed on Table 2.1 should be considered as influencing adult passage.

- Channelization. Channelization is an important factor in solving the upstream fish passage problem and should be emphasized.

- Sprinkler Irrigation. Sprinkler irrigation appears to be a potential alternative for reducing surface water withdrawals and should be assessed in conjunction with direct water diversions from the Lemhi River.

- Purchase Water Rights. Purchasing partial or entire water rights would allow more water to remain in the river.

- Purchase Land. Land purchased for the purpose of securing instream water rights could be resold without the rights, used for fishermen access or recreation, or reclaimed for wildlife habitat.

The benefits analysis also should consider the acceptability of each alternative solution to landowners.

Based on the above considerations, OTT developed four ehnhancement options (A through D). Each option is described in Table 5.1. Option A includes permanent diversion dams and channelization to promote fish passage at the most critical lower Lemhi River reaches. Option C covers both critical and problem passage reaches (where migration blockages occur less freauently). Options B and D are identical to A and C, respectively, except that stream flow is augmented through water rights purchases. Each enhancement option is analized with respect to four fisheries management alternatives.

MANAGEMENT ALTERNATIVES

For each enhancement option, OTT evaluated four fisheries management alternatives. These alternatives reflect OTT's

TABLE 5.1

ENHANCEMENT OPTIONS

OPTION	DESCRIPTION	AUGWENTED FLOW (cfs)
A	Permanent diversion and levee construction at L-5, L-6, and L-7; riverbed channelization at L-5, L-6, L-7, SPSl, SPS2, and SPS3.	0.0
B	Option A plus: flow augmentation through partial water rights purchase and increased water application efficiency (by improving flood irrigation practices or installing sprinkler systems).	
	From L-7 to L-6	
	Flood Irrigation Improvements	5.0
	Sprinkler Systems	8.4
	From L-6 to Mouth	
	Flood Irrigation Improvements	12.5
	Sprinkler Systems	20.9*
C	Permanent diversion and levee construction at L-5, L-6, L-7, L-20, L-22, L-3lA, L-40, L-41, L-43, L-44, L-45D, and L-61; riverbed channelization at these locations plus SPSl, L-3, SPS2, SPS3, and SPS4.	0.0
D	Option C plus: flow augmentation (described in B).	

* This value is used in the fisheries and benefits analyses for Options B & D and assumes installation of sprinkler systems rather than flood irrigation improvements.

consultations with BPA and IDFG, and represent a range of management alternatives that may be appropriate for the Lemhi River. To the extent that it was compatible with the objectives of the Study, OTT incorporated the management strategy for the Lemhi River identified in the Draft Idaho Anadromous Fish Management Plan (IDFG 1984).

Although the four alternatives evaluated are not the only fisheries management possiblities, this fisheries benefits analysis is confined to alternatives that would result in Options A through D having some net beneficial effect. Each alternative evaluated by OTT assumes that at the time the project is implemented, the expected 1995 juvenile migrant passage conditions in the Columbia and Snake Rivers would be achieved. Thus, the smolt-to-adult survival rate (SAR) for spring chinook is expected to be 1.5 percent and the SAR for steelhead, 5.19 percent.

The following summaries define the evaluated fisheries management alternatives.

MANAGEMENT ALTERNATIVE NO. 1

Using this alternative, chinook salmon runs increase naturally from the current population level; harvest is delayed until full habitat seeding is reached: and juvenile migrants are impaired due to diversion screens and bypasses remaining in their current condition.

Assumptions:

- The spring chinook run builds naturally from the current run size of 330 fish. No harvest is permitted until full seeding of juvenile rearing habitat is achieved.

- A 30-percent and 75-percent reduction in target SAR's exists in the Lemhi River for spring chinook and steelhead, respectively, due to the reduction in the return of adults caused by downstream migrant problems at screened irrigation diversions.

- IDFG continues to release an average of 2,000 surplus hatchery steelhead spawners in the Lemhi River annually.

MANAGEMENT ALTERNATIVE NO. 2

Using this alternative, the chinook run is sustained at current 1evels;a limited harvest is permitted: screen and bypass impairment continues for juvenile migrants as in Alternative No. 1.

Assumptions:

- Spring chinook salmon are harvested at a rate that maintains an escapement of 330 fish. Thus, full juvenile rearing habitat seeding is never achieved.

- A 30-percent and 75-percent reduction in target SAR's exists in the Lemhi River for spring chinook and steelhead, respectively, due to the reduction in the return of adults caused by downstream migrant problems at screened irrigation diversions.

- IDFG continues to release an average of 2,000 surplus hatchery steelhead spawners in the Lemhi River annually.

MANAGEMENT ALTERNATIVE NO. 3

Using this alternative, chinook runs increase naturally from the current population level: harvest is delayed until full habitat seeding is reached; and irrigation diversion screens and bypasses are improved from their current condition.

Assumptions:

- The spring chinook run builds naturally from the current run size of 330 fish. No harvest is permitted until full seeding of juvenile rearing habitat is achieved.

- There is a 75 percent basin-wide improvement in downstream migrant passage conditions at screened irrigation diversions in the Lemhi River.

- IDFG continues to release an average of 2,000 surplus hatchery steelhead spawners in the Lemhi River annually.

MANAGEMENT ALTERNATIVE NO. 4

Using this alternative, supplemental stocking of chinook fry and fingerlings occurs for accelerated run building; and the diversion screens and bypasses are improved.

Assumptions:

- IDFG provides full hatchery supplementation with outplanted juvenile chinook salmon to fully seed available habitat during the first return cycle, but there is no supplementation thereafter.

- No harvest occurs until the first chinook salmon return cycle is completed.

- There is a 75 percent basin-wide improvement in downstream migrant passage conditions at screened irrigation diversions in the Lemhi River.

- IDFG continues to release an average of 2,000 surplus hatchery steelhead spawners in the Lemhi River annually.

BENEFITS TO THE FISHERY

To determine potential fishery benefits resulting from the four enhancement options and the associated fishery management alternatives, Buell & Associates, Inc. conducted an assessment of chinook and steelhead production in the Lemhi River. The following sections describe the assessment methodology and the application of the assessment results to develop fishery and economic benefits. This section is summarized from the Task 3.2 Report prepared for OTT by Buell & Associates, Inc. (February 1986).

SMOLT PRODUCTION

A detailed stream survey was conducted to quantify and describe rearing habitat available for juvenile chinook salmon and steelhead in streams of the Lemhi Basin (Chapter 3). Using the stream survey data, Buell & Associates made estimates of the potential for natural production of spring chinook salmon and summer steelhead smolts in the Lemhi Basin. The estimates consider both current conditions and those that would prevail under each of the enhancement options. The estimates are based upon the quantity and quality of available rearing habitat and upon probable rearing densities of juvenile fish under fully seeded conditions.

Data on the capacity of the upper Lemhi River (Reaches 4, 5, and 6) to produce juvenile spring chinook and summer steelhead were reported by Bjornn (1978). However, estimating the potential for smolt production in the lower Lemhi River (Reaches 1, 2, 3) is difficult because:

- No data on fish production or fish densities in the lower Lemhi River are available.

- The lower Lemhi River has habitat of lower quality than that found in the upper Lemhi. The quality difference is due to stream channelization, stream dewatering, and higher water temperatures. This makes it unreasonable to apply data on fish production per habitat area in the upper Lemhi directly to habitat data collected on the lower Lemhi.

- No data on fish production or fish densities are available for streams similar to the lower Lemhi River. This is because there are few, if any, other streams which have habitat conditions like those found in the lower Lemhi.

- No data are available on the relative longitudinal distribution of juvenile steelhead or chinook salmon in the Lemhi River, or among different types of habitat.

The potential for producing spring chinook and summer steelhead smolts in the lower Lemhi River was estimated through a five-step process:

1. Data collected during a 14-year study (1962-1975) of fish production in the upper Lemhi River suggests that 500,000 smolt-sized migrant chinook and 75,000 smolt-sized migrant steelhead can be produced (Bjornn, pers. comm.). Of these smolt-sized migrants, approximately 65 percent of the chinook and 67 percent of the steelhead will overwinter prior to smoltification and seaward migration. Assuming a 50 percent overwintering survival rate for the migrants (Bjornn, pers. comm.; Chapman, pers. comm.), the upper Lemhi River has a

potential to produce 337,500 spring chinook and 49,988 summer steelhead smolts.

2. The total surface area of each habitat type in each study reach of the Lemhi River and Big Springs Creek was weighted to account for habitat quality differences between the reaches. Weights assigned to habitat within each of the different reaches were based upon observations made durinq the stream survey and upon stream temperatures measured during the summer of 1985. The differences in habitat quality were related to general trends of declining riparian zone conditions, increasing water temperatures, and greater streambed channelization in the downstream direction.

3. Factors used to weight the surface area of each habitat type in each study reach of the Lemhi River and Big Springs Creek are presented in Table 5.2. This includes the factors used for both prevailing (Options A and C) and enhanced (Options B and D) stream flow conditions. The factor for Reach 1 (lower Lemhi River) increased with enhancement to account for a decrease in water temperatures expected to result. Better stream temperature data than are presently available would allow the development of more accurate weighting factors.

4. The potential for smolt production in the upper Lemhi River was apportioned to the weighted surface areas of each habitat type using information on the relative distribution of juvenile chinook salmon and summer steelhead within Idaho streams (Table 5.3). This was done to estimate the number of smolts produced per weiqhted unit area of each habitat type.

TABLE 5.2

HABITAT QUALITY WEIGHTING FACTORS

REACH	QUALITY HABITAT CONDITIONS	WEIGHTING FACTOR Prevailing	Enhanced
1 Lower Lemhi	Poor: extensive channelization Max. summer temp. (1985) = 21.5°C	1/4	1/3
2 Lower Lemhi	Generally fair; extensive channelization Max. summer temp. (1985) = 21°C	1/3	1/3
3 Lower Lemhi	Fair; moderate channelization Max. summer temp. (1985) = 17°C	1/2	1/2
4 Upper Lemhi	Good: minor channelization Max. summer temp. (1985) =	3/4	3/4
5 Upper Lemhi	Generally excellent Max. summer temp. (1985) = 17°C	1/1	1/1
6 Big Springs Cr.	Generally excellent	1/1	1/1

TABLE 5.3

JUVENILE FISH DENSITIES BY HABITAT TYPE

Fish Densities (#/sq yd)

HABITAT TYPE	AGE 0+ CHINOOK	AGE 1+ STEELHEAD
Pool	0.325	0.275
Riffle	0.078	0.077
Run	0.086	0.116
Pocketwater	0.132	0.209
Sidechannel	0.110	0.102
Backwater	4.625	0.075

5. The potential for smolt production in the lower Lemhi River was calculated as the sum of the number which can be produced by the weighted surface area of each of the six habitat types. The estimated potential for spring chinook salmon and summer steelhead smolt production in the lower Lemhi River is given in Table 5.4. Table 5.4 also gives estimates for the upper Lemhi River and for Hayden Creek.

   The Hayden Creek estimates in Table 5.4 are based on a direct application of the juvenile fish densities indicated in Table 5.3 to the surface areas of rearing habitat. The predicted potentials for production of age l+ steelhead and age 0+ chinook were adjusted with a SO- percent overwinter survival rate to yield the smolt production figures given.

SPRING CHINOOK

Under current conditions, the Lemhi Basin is estimated to be capable of producing 483,528 spring chinook smolts. Given a ratio of 1,852 eggs per escaping spawner, and an average egg-to-smolt survival rate of 6.89 percent (Bjornn, 1978), an escapement of 3,789 spring chinook spawners is needed to fully seed available rearing habitat in the basin. This reflects a required smolt-to-adult return rate (SAR) of 0.784 percent in order to maintain the run size if all returning adults escape to spawn.

For enhancement options providing stream flow supplementation (B and D), it is estimated that rearing habitat in the Lemhi Basin will be capable of producing 505,223 spring chinook smolts. Using the same eggs per escaping spawner and egg-to-smolt rates previously noted, an escapement of 3,959 adult spring chinook will be needed to fully seed the available habitat. The same minimum SAR as that for prevailing conditions (0.384 percent) would be .

TABLE 5.4

POTENTIAL CHINOOK AND STEELHEAD SMOLT PRODUCTION

REACH	SPRING CHINOOK SMOLTS		SUMMER STEELHEAD SMOLTS	
	Prevailing Conditions*	Enhanced Conditions**	Prevailing Conditions*	Enhanced Conditions**
UPPER LEMHI (Reaches 4, 5 and 6)	337,500	337,500	49,988	49,988
Reach 3	33,999	33,999	5,624	5,624
Reach 2	60,105	60,105	10,173	10,173
Reach 1	38,741	60,436	5,260	6,786
LOWER LEMHI TOTAL	132,845	154,540	21,057	22,583
HAYDEN CREEK	13,183	13,183	16,690	16,690
TOTAL	483,528	505,223	87,735	89,260

* Options A and C continue prevailing stream flow conditions.

** Options B and D enhance stream flows.

required to maintain a run under enhanced stream flows provided that all returning adults escape to spawn.

A SAR, without harvest, of about 1.5 percent for Snake River stocks of spring chinook is hoped for by 1995. The Draft Anadromous Fish Management Plan for the State of Idaho (IDFG 1984) calls for a SAR without harvest of 1.6 percent. Both of these future rates are optimistic and may not be realized for some time. The production benefits analysis for spring chinook presented in this report assumes that the 1995 target SAR of 1.5 percent has been achieved at the time of project implementation.

Fisheries Management Alternatives Nos. 1 and 2

The SAR for the Lemhi River stock of spring chinook may be substantially lower than the SAR generalized for spring chinook in Idaho. A 30-percent lower SAR has been hypothesized for Lemhi River spring chinook to account for the current reduction in returns of adults caused by delays of downstream migrants at screened irrigation diversions along the Lemhi River (Management Alternatives Nos. 1 and 2).

Table 5.5 gives projected values for the annual harvest of chinook salmon for Management Alternative No. 1. It also gives the estimated harvest providing a small but stable run size at the prevailing escapement of 330 fish in relation to the productive capacity of the basin (Management Alternative No. 2). The number of return cycles required to reach full seeding if no harvest is allowed during that run-building period is listed. In addition, the allowable harvest of adults, after available rearing habitat in the Lemhi Basin has become fully seeded with spring chinook, is given. Information for both current conditions and for each of the enhancement options is provided in the table.

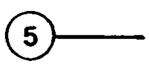
APPENDIX B

TOPOGRAPHIC LOCATIONAL MAPS

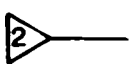
LEGEND - APPENDIX B

LOC# = Ott Water Engineers, Inc. FLow Measurement Stations

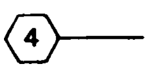
LM# = Lemhi Irrigation District Flow Measurement Station



= Diversion Number and Location



= Reference Number for Critical Passage Sites Chosen for Diversion Structures and Channelization



= Reference Number for Critical Passage Sites Chosen for Channelization Only


= Location of Noted Structures

TABLE 5.5

ANNUAL HARVEST

Option	1995 Target SAR if No Downstrem Migration Impairment at Screened Irrigation Divers ions	Smolts Produced at Full Seeding	SAR with (30%) Downstream Migration Impairment at Screened Irrigation Diversions*	Annual Adult Harvest Providing Stable Run Size of 330 Fish**	Adult Return Cycles Required To Reach Full Seeding***	Allowable Annual Harvest After Full Seeding is Reached***
Current Conditions	1.5%	483,528	1.05%	112	10	1,286
A	1.5%	483,528	1.05%	112	10	1,296
B	1.5%	505,223	1.05%	112	10	1,344
C	1.5%	483,528	1.05%	112	10	1,286
D	1.5%	505,223	1.05%	112	10	1,344

SAR = Smolt-to-adult return rate.

* Fisheries Management Alternatives Nos. 1 and 2.
** Management Alternative No. 2 only.
*** Management Alternative No. 1 only; 10th return cycle, i.e., year 46.

The values given in Table 5.5 are based on a simplified model of conditions affecting the Lemhi stock of spring chinook. The model used to calculate the fish numbers given in Table 5.5 assumes:

- A 30-percent reduction in SAR due to the effects of screened irrigation diversions on outmigrant smolts in the Lemhi River.
- The annual SAR's are constant.
- All adults return at the same age.
- No upstream passage problems present an impairment to returning adults.
- The fishery responds instantaneously to harvested fish in excess of those necessary to fully seed the available rearing habitat.

A simple model of the reductions in chinook spawner success resulting from differing degrees of unfavorable upstream passage conditions is presented in Table 5.6. Numbers of fish given in the table are based upon the same run sizes for each return cycle as those in Table 5.5. The numbers assume a 1.05 percent SAR, which accounts for a 30-percent reduction in adult returns due to delays of downstream migrant smolts at screened irrigation diversions along the Lemhi River.

The model represented by Table 5.6 also assumes:

- The annual SAR's are constant.
- All adults return at the same age.

TABLE 5.6

EFFECT OF PASSAGE CONDITIONS ON SPRING CHINOOK SALMON

Hypothesized Reduction in Spawner Success Due to Poor Upstream Passage Conditions*	Reduction in Number of Successful Spawners if Unfavorable Upstream Passage Conditions Develop During Return Cycle									
	Return Cycle									
	1	2	3	4	5	6	7	8	9	>9
10%	33	44	59	79	106	142	191	255	342	379
25%	83	111	148	199	266	356	477	638	854	947
50%	165	221	297	397	532	712	953	1276	1709	1895

* These conditions would be experienced 2/9 years without passage improvement, l/7 years under Options A and C, and l/13 years under Options B and D.

- Reductions in spawner success during years of poor upstream passage conditions are not reflected by the , number of adults returning from the progeny year class.

- The fishery responds instantaneously to harvest fish in excess of those necessary to fully seed available rearing habitat.

- The fishery does not harvest fish which are not in excess of those necessary to at least replace the parent run.

Tables 5.5 and 5.6 can be used in concert to estimate the benefit of improved adult fish passage and rearing conditions (assuming there is continued impairment of downstream migrants at the screened diversions) under each of the four enhancement options. The benefit to the fishery of each option is reflected in the harvest that would have been lost due to poor passage conditions without passage improvement.

<u>Fisheries Management Alternatives 3 and 4</u>

Management Alternatives 3 and 4 address potential improvements in downstream migration conditions in the Lemhi River associated with irrigation diversion screens. If outmigrant delays and direct losses associated with irrigation diversion screening facilities were reduced significantly, there would be an increase in the smolt-to-adult return rate which would result in faster run building and a greater harvestable surplus of adult fish. The rationale for the assumption that outmigration conditions could improve is based on a cooperative agreement between IDFG and NMFS to install new screening systems at selected diversions. It is not known how much improvement in outmigrant success would accrue from fixing or replacing selected diversion screens. For the two management alternative management evaluations, however, it was arbitrarily decided that the outmigrant success rate could be improved so that 75 percent of the assumed outmigrant losses would be eliminated on a basin-wide basis. Thus, the hypothetical Lemhi River outmigrant success rate for spring chinook would change from 70 percent to 92.5 percent. For summer steelhead the rate would change from 25 percent to 81.25 percent. It is important to note however, that elimination of 75 percent of the outmigrant loss and delay problem, by fixing or replacing some selected screens, may not be an attainable goal: furthermore, it may be prohibitively expensive. Nevertheless, some assumption had to be made to demonstrate the nature of the changes in benefits attibutable to Options A through D resulting from improved screens and bypass systems.

With the improvement in downstream migrant survival discussed above, the Lemhi River SAR for spring chinook would be 1.39 percent; the SAR for summer steelhead would be 4.22 percent. As a result of these increased survival rates, the anadromous salmonid runs in the Lemhi River would be able to sustain themselves without hatchery supplementation.

Fishery benefits for each of the four enhancement Options A through D, were projected for one chinook salmon hatchery supplementation strategy. Management Alternative No. 3 is a continuation of current IDFG activities described previously and involves no hatchery supplementation of the spring chinook run. Management Alternative No. 4 maximizes the value of naturally returning adult chinook, thus increasing the benefits attributable to implementation of the enhancement options. It does this by bringing the Lemhi runs of spring chinook up to full strength as rapidly as possible through intensive hatchery supplementation. Once full run strength is attained, the run depends entirely upon naturally returning adults to seed the system. This strategy would require a chinook fry, fingerling, or smolt outplanting program during (and only during) the first adult return cycle following project implementation.

Management Alternative No. 3

In order to determine the rate of run building and harvestable surplus after full run strength is developed (assuming improvement in downstream migration conditions), Tables 5.7 and 5.8 were constructed. These tables are analogous to Table 5.5 and 5.6. Table 5.7 presents the harvestable surplus with and without implementation of Options A through D under good upstream migration conditions. Table 5.8 presents the harvestable surplus with and without implementation of the options under impaired upstream migration conditions. Both these tables assume no supplementation of the natural chinook run with hatchery juveniles or adults.

Fishery benefits projected for each of the four enhancement options are:

options A, C - +100.24 adults harvested/yr (yrs 26-50)

Options B, D - +6.19 adults harvested/yr (yrs 26-30)
+309.19 adults harvested/yr (yrs 31-50)

The increases in harvested adults for Options A and C are derived by multiplying the difference in frequency of occurrence for run impairment (with and without project implementation) by the reduction in harvest that would be produced by impairment. The increases in harvested adults for Options B and D are derived by adding increases due to increased rearing habitat (provided by those options) to the benefits produced by Options A and C.

Management Alternative No. 4

Tables 5.9 and 5.10 estimate the increased spring chinook harvest derived from implementation of each of the enhancement options under Management Alternative No. 4. The estimates assume full

TABLE 5.7

ANNUAL HARVEST OF CHINOOK SALMON BY RETURN CYCLE DURING
FAVORABLE ADULT PASSAGE CONDITIONS

Option	Smolts Produced at Full Seeding	SAR if Current Downstream Migration Conditions in the Lemhi River are Improved 75 Percent	Return Cycle						
			1	2	3	4	5	6	>6
No Project	483,528	1.39%	Ø	Ø	Ø	Ø	Ø	1794	2918
A, C	483,528	1.39%	Ø	Ø	Ø	Ø	Ø	1794	2918
B, D	505,223	1.39%	Ø	Ø	Ø	Ø	Ø	1621	3048

Note: The figures given here assume no hatchery supplementation of the chinook population.

TABLE 5.8

REDUCTION IN ANNUAL HARVEST WHEN UNFAVORABLE ADULT PASSAGE CONDITIONS DEVELOP

Hyposthesized Reduction in Spawner Success	Option	Frequency of Problem	Return Cycle						
			1	2	3	4	5	6	>6
25%	No Project	2/9 years	0	0	0	0	0	1263	1263
	A, C	l/7 year	0	0	0	0	0	1263	1263
	B, D	l/13 years	0	0	0	0	0	1320	1320

Note: The figures given here assume a 75 percent improvement of downstream migration conditions in the Lemhi River and no hatchery supplementation of the chinook population.

TABLE 5.9

ANNUAL HARVEST OF CHINOOK SALMON BY RETURN CYCLE DURING
FAVORABLE ADULT PASSAGE CONDITIONS

Option	Smolts Produced at Full Seeding	SAR if Current Downstream Migration Conditions in the Lemhi River are Improved 75 Percent	Return Cycle 1	Return Cycle >l	Increased Annual Harvest Due to Project
No Project	483,528	1.39%	Ø	2918	Ø
A, C	483,528	1.39%	Ø	2918	Ø
B, D	505,223	1.39%	Ø	3048	130

Note: The figures given here assume hatchery supplementation during the first return cycle which fully seeds available rearing habitat with juvenile salmon. Full run strength is realized during the second return cycle.

TABLE 5.10

REDUCTION IN ANNUAL HARVEST WHEN
UNFAVORABLE ADULT PASSAGE CONDITIONS DEVELOP

Hypothesized Reduction in Spawner Success Due to Poor Upstream Passage Conditions	Option	Return Cycle 1	Return Cycle >l
25%	No Project	Ø	1263
	A, C	Ø	1263
	B, D	Ø	1320

Note: The figures given here assume full seeding of available rearing habitat during the first return cycle as a consequence of hatchery supplementation.

hatchery supplementation of the run for one adult return cycle. Outplanted juveniles would be used to supplement and fully seed available rearing habitat during the first return cycle, but there would be no supplementation thereafter. Tables 5.9 and 5.10 are analogous to Tables 5.5 and 5.6. The benefits projected for each of the four options are:

Options A, C - +100.24 adults harvested/yr (yrs 6-50)

Options B, D - +309.19 adults harvested/yr (yrs 6-50)

STEELHEAD

Under current conditions, the Lemhi Basin is estimated to have the capacity to produce 87,735 summer steelhead smolts. Assuming survival rates of 50 percent for the egg-to-fry stage, and 1.93 percent for the fry-to-smolt stage, 104 steelhead eggs must be deposited per smolt produced. Given an average fecundity of 5,500 eggs per female spawner and a spawning escapement in the Lemhi River, which averages 64 percent females (Bjornn, 1978), 3,520 steelhead eggs will be deposited per returning steelhead spawner (both sexes). This means each returning spawner represents the production of approximately 34 smolts in the progeny year class of summer steelhead. It also indicates that:

- A spawning escapement of 2,583 summer steelhead is necessary in order to get full production of 87,735 smolts from the basin.

- A smolt-to-adult return rate of 2.94 percent, without harvest, is needed to maintain the run.

For the enhancement options that provide stream flow augmentation (B and d), it is estimated that the Lemhi Basin will be capable of producing 89,260 smolts. Given the SAR required for run maintenance without harvest (2.94 percent), it is projected that an escapement of at least 2,628 adult steelhead will be needed to fully seed available rearing habitat in the Lemhi under Options B and D.

The historical SAR for summer steelhead produced in Idaho streams was about 5.0 percent (Raymond, 1980). This rate has been substantially reduced by fish losses related to hydroelectric dams on the Columbia and Snake Rivers. However, recent improvements in the survival rates of steelhead migrant passage through the Snake and Columbia Rivers have raised the hope that, for Idaho stocks, SAR's may attain the historical condition. These hopes are optimistic, but lacking better information on the future SAR's for Idaho steelhead, a target SAR of 5.19 percent, without harvest, is used in this analysis of project benefits (USACE, 1985).

Management Alternative Nos. 1 and 2

The SAR for steelhead in the Lemhi Basin is presently lower than the SAR generalized for all summer steelhead in Idaho. One study suggests that returns of adult steelhead to the Lemhi Basin might be reduced by as much as 90 percent. This is caused by delays of downstream migrating smolts at screened irrigation diversions along the Lemhi River (Bjornn, pers. comm,). Given this reduction in downstream migrant success and subsequent adult returns, the anticipated SAR for Idaho's steelhead (5.19 percent) was reduced by 75 percent (to 1.30 percent). It was then applied to Lemhi Basin steelhead to account for the effects of downstream migrant delays taking place at irrigation diversions. The 75-percent reduction of the SAR is a generous assumption in the steelhead production model.

The analysis presented here indicates that sustained natural production of steelhead in the Lemhi Basin is not possible under current conditions, or the enhanced conditions of Options A .

through D. In recent years, IDFG has supplemented the annual run with the release of large numbers of excess hatchery spawners. The SAR required for run maintenance (estimated at 2.94 percent) has not been realized for many years and is not expected in the future, either under prevailing conditions or the proposed enhancement options, assuming Management Alternatives Nos. 1 or 2 are implemented. For the purposes of this benefits analysis, it is assumed that the IDFG will continue to release an average of 2,000 surplus hatchery spawners (1982-1984 average) of two females per male into the Lemhi Basin to maintain the run of steelhead returning to the river each year.

Table 5.11 gives estimates of the annual natural adult return and allowable harvest of summer steelhead in the Lemhi Basin, with and without annual supplementation of hatchery spawners, for current and enhanced conditions.

The numbers in Table 5.11 assume:

- A 75-percent reduction in SAR from 5.19 to 1.30 due to the effects of screened irrigation diversions on downstream migrants in the Lemhi River.

- Rearing habitat is fully seeded.

- The spawning run (with supplementation) is at full strength.

- No improvement in downstream passage conditions as a consequence of habitat enhancement.

- The annual SAR is constant.

- All upstream passage problems have theoretically been solved.

TABLE 5.11

STEELHEAD RETURNS AND HARVESTABLE ADULTS
FOR FISHERIES MANAGEMENT ALTERNATIVES NOS. 1 AND 2

Option	Smolts Produced at Full Seeding	Returning Adults per Smolt*	Natural Adult Return	Annual Harvestable Surplus Without Hatchery Supplements	Annual Harvestable Surplus with Outplantings of 2,000 Spawners	Annual Harvest in Excess of Current Conditions
Current Conditions	87,735	1.30%	1,141	Ø	641	Ø
A	87,735	1.30%	1,141	Ø	641	Ø
B	89,260	1.30%	1,160	Ø	615	-26
C	87,735	1.30%	1,141	Ø	641	Ø
D	89,260	1.30%	1,160	Ø	615	-26

* Assumes no benefit to downstream migrant smolts as a consequence of enhancement.

- The fishery responds instantaneously to harvest fish in excess of those necessary to fully seed available rearing habitat.

- Only fish in excess of those necessary to fully seed available habitat are harvested.

The allowable harvests given in Table 5.11 indicate that there will be no surplus of spawners for harvest unless the spawning run is supplemented each year with excess hatchery spawners. The figures assume that naturally-returning adult steelhead are those harvested while all planted hatchery spawners are allowed to escape. This means the natural stock is being continually replaced with hatchery fish under the hatchery supplementation scenario. This may not be a good situation biologically, but it allows the greatest harvest of adult steelhead, and thus the greatest benefit to the fishery in the short term.

When flow is added to the lower Lemhi River under Options B and D, the allowable harvest is reduced. This occurs because the natural run is not replacing itself. These options use more of the naturally-returning adults to fully seed available habitat than those project options not increasing stream flow in the Lemhi River.

Table 5.12 presents a simple model of the effect of poor upstream passage conditions for fish in the Lemhi River under prevailing and proposed conditions. The model presented is based upon the same assumptions as those used to develop the fish numbers presented in Table 5.11, with the exception that upstream passage is assumed to reduce adult escapements, and thus reduce the allowable harvest of fish during certain years. Table 5.12 presents losses of adults attempting to return to the spawning grounds, and consequent reductions in the allowable harvest. The losses presented in Table 5.12 would not occur annually, but at the frequencies of low flows discussed in Chapter 3.

TABLE 5.12

EFFECT OF PASSAGE CONDITIONS

Option	Hypothesized Reduction in Spawner Success Due to Poor Upstrean Passage Conditions (%)	Predicted Frequency of Poor Passage Conditions (Yrs/Yrs)	Natural Return of Adults	Harvestable Adults without Hatchery Plants	Harvest With Plants of 2,000 Spawners	Reduction in Harvestable Wults with Plants of 2,000 Spawners
Current Conditions	10				585	56
	25	2/9	1,141	Ø	474	167
	50				141	500
A	10				585	56
	25	1/7	1,141	Ø	474	167
	50				141	500
B	10				554	61
	25	1/13	1,160	Ø	433	182
	50				70	545
C	10				585	56
	25	1/7	1,141	Ø	474	167
	50				141	500
D	10				554	61
	25	1/13	1,160	Ø	433	182
	50				70	545

Tables 5.11 and 5.12 were used in concert to estimate the benefits of improved fish passage and rearing conditions, with downstream migration impairment, under each of the enhancement options. The estimates were made in the same fashion as those for spring chinook using Tables 5.5 and 5.6.

Management Alternative Nos. 3 and 4

These two fisheries management alternatives include a 75 percent basin-wide improvement to the fish screening and bypass facilities on the Lemhi River. Table 5.13 and 5.14 present the increased summer steelhead harvests derived from implementation of each of the enhancement options in the presence of improved downstream migration conditions. Results depend on IDFG continuing to release 2,000 surplus hatchery spawners in the Lemhi River each year. The two tables are analogous to Tables 5.11 and 5.12 presented previously. Fishery benefits projected for each of the four options are:

Options A, C - +13.25 adults harvested/yr (yrs 3-50)

Options B, D - +43.11 adults harvested/yr (yrs 3-50)

These changes in annual harvest were determined in the same way as those for chinook salmon.

ECONOMIC BENEFITS

The economic benefits of implementing each of the enhancement options were computed using standard economic analysis techniques. It is emphasized that benefit/cost analyses are only one tool available to decision makers in evaluating the merits of a proposed project. The implementation of measures to mitigate, restore, or enhance the Columbia Basin anadromous fishery does not require a favorable benefit/cost determination (P.L. 96-501).

TABLE 5.13

ANNUAL STEELHEAD HARVEST DURING FAVORABLE ADULT PASSAGE CONDITIONS

Option	Smolts Produced at Full Seeding	SAR if Current Downstream Migration Conditions in the Lemhi River are Improved 75 Percent	Annual Adult Return	Adult Fish Harvested	Increased Annual Harvest Due to Project
No Project	87,735	4.22%	3702	1119	Ø
A, C	87,735	4.22%	3702	1119	Ø
B, D	89,260	4.22%	3767	1139	20

Note: The figures given here assume an annual planting of 2,000 surplus hatchery spawners and a 75 percent improvement of downstream passage conditions in the Lemhi River.

TABLE 5.14

REDUCTION IN ANNUAL STEELHEAD HARVEST WHEN UNFAVORABLE ADULT PASSAGE CONDITIONS DEVELOP

Option	Hypothesized Reduction in Spawner Success Due to Poor Unstream Passage conditions	Predicted Frequency of Poor Passage Conditions (Yrs/Yrs)	Adults Required to Fully Seed Available Rearing Area	Natural Return of Adults	Harvest with Plants of 2,000 Surplus Hatchery Spawners	Reduction in Harvest with Plants of 2,000 Hatchery Spawners
No Project	25%	2/9	2583	3702	3035	167
A, C	25%	l/7	2583	3702	3035	167
B, D	25%	l/13	2628	3767	3040	182

Note: The figures ginen here assume an annual planting of 2,000 surplus hatchery spawners and a 75 percent improvement of downstream passage conditions in the Lemhi River.

However, the goal of achieving sound biological objectives at minimum economic cost is recognized by that legislation.

The analysis of economic benefits for implementing the options analyzed for improving anadromous fish production in the Lemhi River Basin is based on the projected increase in anadromous fish harvest each option would produce. All of the various options analyzed would improve upstream migration conditions for adult spawners in certain years. Two of the four options, B and D, would increase available juvenile rearing habitat in all years. Based upon stream flow availability, the effects on harvestable adult fish due to Options A and C are identical, and the effects of Options B and D are identical (Table 5.1). Therefore, the analysis of economic benefits of implementation considers A and C together, and B and D together.

The benefits of anadromous fish enhancement projects are measured by the number of adult fish available to the combined sport and commercial fishery, and to the values attributed to harvested fish. The numbers of fish available to the combined fishery (increase in harvestable surplus) were previously given for each set of options developed.

The economic values ascribed by economists to fish taken in various components of the combined fishery vary widely, depending on available data and the sets of assumptions employed. In the case of upriver anadromous fish stocks, the goal of the Northwest Power Planning Council's Fish and Wildlife Program is to restore production levels. This suggests that compensatory values be used. The Economic and Environmental Principals and Guidelines for Water and Related Land Resources Implementation Studies acknowledges the lack of reliable empirical methods for evaluating the willingness to accept compensation for losses. That document indicates enhancement values be used for both losses and gains. Values based on willingness to pay (enhancement values) and willingness to sell (compensatory values), attributed by various economists to Idaho steelhead trout and chinook salmon, were reviewed by McKern (pers. comm.) and discussed by the USACE (1985). Enhancement values are used for sport-caught fish and compensation values are used for commercially-caught fish in this analysis. Values for each stock, each segment of the fishery, and the combined values (adjusted for inflation) are tabulated below:

Stock	$/Fish	% of Catch	Combined $
Spring chinook (sport)	125.00	57	89.36
Spring chinook (commercial)	42.12	43	
Summer steelhead (sport)	75.00	82	65.43
Summer steelhead (commercial)	21.81	18	

The discount rate used in this analysis is three percent. This is the risk-free rate of time preference specified by the Bonneville Power Administration for use in analyses such as this. Reasons for this rate include, among others, the balance of risk or uncertainty associated with various components of the analysis, and the level of institutional and public concern for the future of anadromous fish runs in the region. The project life is set at 50 years.

The economic analysis of benefits for implementing Options A-D is relatively straight forward for any effects which are continuous after implementation, or change at a constant rate over time. The increase in available rearing habitat for juvenile salmon and steelhead projected by Options B and D is such an effect. However, relief from impaired upstream passage of adult fish is not such an effect. Instead, the effect of implementing various options is to increase the size of the recurrence interval (decrease the probability of occurrence) for upstream passage impairment. In this case, the monetary benefits of implementing an option must be adjusted according to the probability of occurrence of adult passage impairment due to flow. Probabilities of the occurrence of upstream adult migration impairment associated with present conditions, and with each of the options evaluated are:

Existing Conditions	P = 0.222
Options A, C	P = 0.143
Options B, D	P = 0.0769

The benefits of implementing various options arise primarily from the avoidance of upstream passage impairment. Whenever this event occurs, the fishery must forego the harvest of those fish needed to ensure sufficient seeding of the Lemhi Basin in spite of passage problems. To the extent that passage problems are avoided, the combined fishery can realize its normal harvest. The benefit is in terms of an avoided cost.

The cost of each occurrence of upstream passage impairment is the product of the number of fish which could have been harvested, under unimpaired passage conditions, and the combined value per fish for that stock. This product is termed the occurrence cost. The product of the occurrence cost and the probability of occurrence is the expected annual cost of passage impairment. The present worth of passage impairment over the project lifetime is determined by calculating the present worth of the expected annual cost of passage impairment over that time period as a uniform annual series. Naturally, these values are negative and represent economic losses. The economic benefit of implementating an option is the difference between the present value of passage impairment (loss) under existing conditions, and the value projected for conditions following implementation.

Table 5.15 summarizes the economic benefits of implementing the four options over a project lifetime of 50 years. Benefits are calculated separately for summer steelhead and spring chinook

TABLE 5.15

SUMMARY OF ECONOMIC BENEFITS

ALTERNATIVE/OPTION	BENEFIT ($) Chinook	Steelhead	Total
Management Alternative No. 1			
A, C	11,044	22,313	33,357
B, D	19,737	(4,863)	14,874
Management Alternative No. 2			
A, C	20,437	22,313	42,750
B, D	37,417	(4,863)	32,554
Management Alternative No. 3			
A, C	74,493	20,352	94,845
B, D	170,513	64,541	235,054
Management Alternative No. 4			
A, C	189,447	20,352	209,799
B, D	584,244	64,541	648,785

salmon. The negative benefit for steelhead, with Management Alternatives Nos. 1 and 2, represents the loss to the fishery of 26 fish annually needed to escape harvest and seed the extra habitat provided by Options B and D. This occurs only because the run is supplemented with a fixed number of hatchery spawners (i.e., 2,000). If the run was supplemented with 2,026 hatchery spawners, or self-sustaining with even a small harvestable surplus, the negative benefit would disappear as with Management Alternatives Nos. 3 and 4.

This analysis of project benefits assumes improved passage conditions both upstream and downstream, throughout the Columbia and Snake River systems. It reflects the aims of the Northwest Power Planning Council's Fish and Wildlife Program, and the proposed long-term salmon and steelhead production and harvest goals of the State of Idaho. Thus, the calculated benefits of implementing project options are contingent on the improvement of mainstem passage conditions and, in the case of Management Alternatives Nos. 3 and 4, improving downstream migrant success at irrigation diversion screens and bypasses on the Lemhi River.

Analyses of project benefits derived from Management Alternatives Nos. 3 and 4 are particularly important. They show the beneficial effect that improved downstream passage conditions at irrigation screening facilities in the Lemhi River will have on the run of anadromous fish. By assuming a 75 percent reduction in the losses and delays at screening facilities, some of the projected project benefits become substantial, particularly for Options B and D where the fish are managed for the maximum natural run.

Other factors regarding the Lemhi River and the future of its anadromous fish stocks need to be considered. IDFG has recently indicated it may manage the Lemhi River fish runs as hatchery-supplemented runs on a continuing basis, rather than on the short-term basis assumed in Management Alternative No. 4

(Holubetz, pers. comm., January 1986). Specifically, the juvenile population of chinook salmon would be supplemented with hatchery fingerlings or fry to achieve full seeding whenever adult escapement is below that necessary for full natural seeding. In addition, 550,00 chinook smolts would be outplanted to the upper watershed each year to imprint then migrate. The adult fishery would be targeted on hatchery fish, not naturally-reproduced fish. The harvest rate is expected to range between 5 and 20 percent of the adults returning as far as the mouth of the Lemhi River, with other river and ocean harvests added in. This management scenario could result in a consistent over-harvest of naturally reproducing adults, but the commitment by IDFG to seed the Lemhi River with hatchery fry or fingerlings is intended to keep adult returns high enough for a significant harvestable surplus.

Such a management program would have significant implications for the enhancement options evaluated by OTT. The commitment to seed with hatchery fry or fingerlings and the outplanting of 550,000 smolts per year would eliminate the necessity for correction of upstream migration impairment. Downstream migration problems are to be addressed by NMFS. The only benefit to the Lemhi River salmon and steelhead stocks from the enhancement options would be increased rearing habitat provided by Options B and D. These benefits would be marginal in the face of the proposed smolt outplanting program. Thus, if IDFG implements the full-scale hatchery supplementation program as described, then the options evaluated by OTT should be considered alternatives to the supplementation program, not an adjunct to it.

CHAPTER 6

BENEFIT/COST ANALYSIS

The objective of a benefit/cost analysis is to determine the economic merits of a project. When the benefits and costs of the project are determined on a consistent present worth basis, and the benefits are greater than the costs (a B/C ratio greater than 1.01, the project is considered "in the public interest" and therefore economically justified. It is important to emphasize that a B/C ratio greater than 1.0 is not required for implementation of Fish and Wildlife Program projects, such as the Lemhi River Habitat Improvement Program.

BENEFITS

Benefits of implementing any of the four enhancement options are assumed to result from harvests of adult salmon and steelhead that would have been lost under existing conditions in the Lemhi. It is estimated that low flows in the Lemhi cause a loss of harvestable fish at a recurrence interval of two in nine years under existing conditions. Implementation of Options A or C would increase this recurrence interval to one in seven years, and implementation of Options B or D would increase it to one in thirteen years. Benefits of the four options are the difference between harvest lost under existing conditions, and harvest lost under the various options.

CHINOOK

Four fisheries management alternatives are presented in Chapter 5 for chinook salmon. The first alternatve involves no harvest of fish until the run has fully seeded the available habitat, in approximately 46 years. Then benefits begin to accrue as discussed above. The second alternative involves a harvest of 112 fish per year and the maintenance of a small but stable run of 330 fish. Alternatives 1 and 2 do not require improvements to the irrigation diversion screens or bypasses from prevailing conditions. The third alternative is identical to the first except that the screens and bypasses are improved. The fourth alternative incorporates the third alternative plus supplements juvenile fish production to immediately restore the fish runs to their maximum capacity. These four alternatives will result in a different B/C ratio for each. Chinook benefits resulting from the proposed options are presented in Chapter 5.

STEELHEAD

Project benefits derived from steelhead are based on a loss of harvestable fish due to upstream passage conditions. Unlike chinook, only one management program is considered. It is assumed that IDFG will continue to stock 2,000 surplus hatchery spawners annually in the Lemhi. The benefit of this program under the four enhancement options are evaluated. Steelhead benefits and the harvest scenario are presented in Chapter 5.

COSTS

The cost of implementing the four options was determined, and costs were separated into capital and annual costs and are presented in Table 6.1.

PRESENT WORTH ANALYSIS

In Chapter 5, the present worth of benefits for chinook and steelhead were determined assuming a three percent discount rate and a SO-year project life. The same assumptions are used to calculate the present worth of annual costs for the four options.

TABLE 6.1

CAPITAL AND ANNUAL COSTS FOR OPTIONS A, B, C, AND D

OPTION	($) CAPITAL COST	($) ANNUAL COST
A	1,386,000	11,300
B	1,734,000	11,300
C	4,219,000	42,900
D	4,567,000	42,900

Table 6.2 presents the capital costs, present worth of annual costs, and present worth of benefits for the four options for each of the four fisheries management alternatives.

BENEFIT/COST RATIOS

In Table 6.2 the total cost of the four options and the present worth of benefits are given in columns 5 and 6, respectively. The B/C ratios for the various options, under the four fisheries management alternatives, are computed by dividing the value in column 6 by the value in column 5. The results are presented in Table 6.3.

TABLE 6.2

COSTS AND BENEFITS OF THE FOUR ENHANCEMENT OPTIONS

FISHERIES MANAGEMENT ALTERNATIVE	OPTION	CAPITAL COST ($)	PRESNET WORTH OF ANNUAL COSTS ($)	TOTAL COST ($)	PRESENT WORTH OF BENEFITS ($)
1	A	1,386,000	290,700	1,677,000	33,400
	B	1,734,000	290,700	2,025,000	14,900
	C	4,219,000	1,104,000	5,323,000	33,400
	D	4,567,000	1,104,000	5,671,000	14,900
2	A	1,386,000	290,700	1,677,000	42,800
	B	1,734,000	290,700	2,025,000	32,600
	C	4,219,000	1,104,000	5,323,000	42,800
	D	4,567,000	1,104,000	5,671,000	32,600
3	A	1,386,000	290,700	1,677,000	94,800
	B	1,734,000	290,700	2,025,000	235,100
	C	4,219,000	1,104,700	5,323,000	94,800
	D	4,567,000	1,104,000	5,671,000	235,100
4	A	1,386,000	290,700	1,677,000	209,800
	B	1,734,000	290,700	2,025,000	648,800
	C	4,219,000	1,104,700	5,323,000	209,800
	D	4,567,000	1,104,000	5,671,000	648,800

TABLE 6.3

BENEFIT/COST RATIOS FOR THE FOUR OPTIONS

FISHERIES MANAGEMENT ALTERNATIVE	OPTION	B/C
1	A	0.020
	B	0.007
	C	0.006
	D	0.003
	A	0.026
	B	0.016
	C	0.008
	D	0.006
3	A	0.056
	B	0.116
	C	0.028
	D	0.041
4	A	0.125
	B	0.320
	C	0.039
	D	0.114

CHAPTER 7

RESULTS AND CONCLUSIONS

The Lemhi River Habitat Improvement Study has focused on identifying and analyzing solutions to fish passage problems in the Lemhi River. The Study followed a process of identifying alternative solutions, performing data collection and background analyses, evaluating alternatives, and developing and assessing implementation options.

EVALUATION OF ALTERNATIVES

A task report, which described the nine enhancement alternatives, was produced for the BPA and participating agencies. A meeting was held on September 11, 1985 between representatives from the BPA, IDFG, OTT, and Buell & Associates Inc., to discuss the nine enhancement alternatives presented in the task report. OTT was directed to focus on alternatives to improve upstream passage, since an existing program sponsored by NMFS is addressing downstream passage problems. Table 7.1 presents an evaluation of the nine enhancement alternatives. The table includes agency comments and results of analyses performed as part of the Study.

Evaluation of the enhancement alternatives lead to the elimination of all alternatives except flow concentration and water withdrawal reduction by improved flood irrigation and sprinkler irrigation. These alternatives were developed into the four options discussed in Chapter 5. Each option was evaluated in conjunction with four fisheries management alternatives.

EVALUATION OF OPTIONS

Options A and C would improve upstream passage conditions in the lower Lemhi River by providing passage around critical diversions

TABLE 7.1

EVALUATION OF ALTERNATIVES

ALTERNATIVE	DESCRIPTION	EVALUATION
1. Flow Concentration	Construct permanent diversions and the channelize riverbed at critical and problem locations.	The most frequent and severe blockage occurs at diversions L-5, L-6, and L-7, and should be considered for replacement. Channelization is vital in solving upstream passage problems, and should be included.
2. Fish Screen Improvement	Improve fish screen systems at irrigation diversions.	NMFS funds a program to maintain and improve screens and bypasses, no further consideration should be given to this alternative. However, it is recommended that IDFG accelerate drum screen replacements and conduct prototype experiments to test various screen/bypass systems.
3. Groundwater Augmentation	Pump groundwater to directly augment flow in the River.	Lack of information on the aquiter and the potential low yield of wells make this unfeasable.
4. Groundwater Irrigation	Replace partial or entire surface water irrigation withdrawals with groundwater.	Unfavorable because of the estimated low well yields, interference, and cost. Not economically feasible for irrigators.

TABLE 7.1
(continued)

ALTERNATIVE	DESCRIPTION	EVALUATION
5. Water Withdrawal Reduction	Purchase partial surface water rights from irrigators in exchange for more efficient flood irrigation, or else directly purchase land.	Marginally feasible to irrigators based on general analysis. 12.7 cfs from L-6 to the mouth could be conserved if 60% of land irrigated by L-6 and L-7 were included in the program. Unless the benefits of converting land to wildlife habitat or recreational area are significant, the option of directly purchasing land and not reselling it appears expensive.
6. Return Flow Improvement	Increase drainage from irrigated fields, drain marsh areas, and perched water tables.	Lack of data make this alternative difficult to evaluate. Major problems with interrupting groundwater returns and degrading water quality in the river.
7. Sprinkler Irrigation	Replace inefficient flood irrigation with sprinkler systems using surface water.	Favorable for conserving surface water. Considered only for the lower Lemhi reaches. 20.9 cfs could be conserved if 60% of the land irrigated by L-6 and L-7 were placed under sprinkler irrigation.
8. Storage	Construct a storage reservoir on Hayden Creek.	High capital cost makes this alternative unfeasible.
9. Trap and Haul	Construct trap and haul facilities for upstream adult and downstream juvenile migration.	An upstream trapping operation is in place for low flow years. IDFG does not consider this a viable alternative due to high operating costs.

and through shallow areas by means of an excavated channel. This is estimated to increase the recurrence interval of adult impairment from two in nine years to one in seven years. This would result in a benefit of between approximately $33,000 and $210,000 (present worth of benefits over 50 years) to the chinook and steelhead stocks of the Lemhi depending on the fisheries management alternative select. The total cost for implementing Options A and C, including the present worth of annual costs, is $1.7 million for Option A and $5.3 million for Option C.

Options B and D would improve upstream passage conditions similar to A and C, however, an additional flow of approximately 21 cfs would be available in the lower reach of the River. This is estimated to increase the recurrence interval of adult impairment from two in nine years to one in thirteen years. The additional flow would increase smolt production for chinook salmon by roughly 22,000 smolts. Implementation of Options B or D would result in a benefit of between approximately $25,000 and $649,000 (present worth of benefits over 50 years) to the chinook and steelhead stocks of the Lemhi depending on the fisheries management alternative selected. Total costs for Options B and D are approximately $2.0 million and $5.7 million, respectively.

The benefit/cost ratios of the four options and management alternatives range from 0.003 to 0.320. The greatest ratio is for Option B, coupled with screen improvements and supplementation of juvenile chinook sufficient to fully seed available rearing habitat. Details of the benefits analysis and the benefit/cost analysis are given in Chapters 5 and 6.

CONCLUSIONS

The benefit analysis suggests that the project is not economically attractive. A fundamentally different approach in determining benefits may be possible, and it may show the project to be economically attractive. An aesethic or cultural value could be placed on adult salmon and steelhead returning to the Lemhi River that are not harvested. The analysis presented in Chapter 5 considers only benefits from harvestable adults that would be lost under existing conditions.

The analysis of project benefits shows the beneficial effect that improved downstream passage conditions at irrigation screening facilities in the Lemhi River will have on its run of anadromous fish. By assuming a 75-percent reduction in the hypothetical losses and delays at screening facilities, some of the projected benefits become substantial, particularly Options B and D where the fish are managed for a maximum natural run.

The success of augmenting stream flow by purchasing water rights and improving irrigation efficiency will depend on the magnitude of benefits realized by participating irrigators. The income received from the sale of a portion of an irrigators water right must be greater than the cost of land improvements, equipment, and operation and maintenance.

RECOMMENDATIONS

The results of this Study as reflected in the benefits and costs of the four enhancement options and the four fisheries management alternatives evaluated, indicate that a combination of Options B and Management Alternative 4 will result in the greatest B/C ratio attainable. OTT recommends this combination which includes:

- Permanent diversion and levee construction at L-5, L-6, and L-7; riverbed channelization at L-5, L-6, L-7, SPSl, SPS2, and SPS3.

- Flow augmentation through partial water rights purchase and increased water application efficiency through improved flood irrigation practices or installation of sprinkler systems.

- A 75 percent basin-wide improvement in downstream migrant passage conditions at screened irrigation diversions exists over prevailing conditions at the time the project is implemented.

- Chinook supplementation to fully seed juvenile rearing habitat is implemented for the first chinook return cycle only.

- Harvest is delayed until the first chinook return cycle is completed.

- IDFG annually stocks about 2,000 surplus hatchery steelhead spawners in the Lemhi River.

The benefits accured from this option and management alternative derive primarily from:

- Reduced frequency of low-flow conditions impairing fish passage.

- Enhanced production due to increased chinook rearing habitat.

- Immediate run building to chinook habitat capacity thus allowing the benefits of harvest to be accrued over a longer time period.

The success of this recommended option is largely dependent on having improvements to the screened irrigation diversions in place at the time the project is implemented. It is easy to see that the benefits from the four options are significantly improved if the screen improvements are made prior to project implementation. Without screen improvements the potential project benefits are largely lost. In OTT's view, the Study results strongly suggest that screen improvements be completed prior to selecting and implementing any enhancement option or fish management alternative. OTT recommends that serious consideration be given to completing diversion screen and bypass, after having completed the recommended bypass prototype testing described in Chapter 4, improvements as a prerequiste to implementing an enhancement option or management strategy.

OTT recognizes that the success of fisheries management in the Lemhi River depends, in part, on conditions outside of Lemhi, (e.g., Columbia and Snake Rivers). The Fisheries Management Alternatives evaluated were relatively simple management strategies. The complex and complicating issues of a mixed stock fishery and the attainability of target 1995 SAR's were not examined. OTT recommends that after IDFG selects the fishery management strategy it intends to pursue for the Lemhi River, that a more detailed model of production and harvest be developed prior to project implementation. Such a model should allow the fine tuning of expected fisheries benefits and will be useful in designing and implementing a successful enhancement program for the Lemhi River.

REFERENCES

REFERENCES

Anderson, A.L. 1961. Geology and Mineral Resources of the Lemhi Quadrangle, Lemhi County, Idaho: Moscow, Idaho, Idaho Bureau of Mines and Geology Pamphlet 124, 111 p.

Bell, M.C. 1984. Fisheries Handbook of Engineering Requirements and Biological Criteria. U.S. Army Corps of Engineers, North Pacific Division. Portland, Oregon.

Bjornn, T.C. and R.R. Ringe, "Evaluation of Conditioning Steelhead Trout in Cold Water after Rearing at 15°C, Technical Report 84-3", Idaho Cooperative Fishery Research Unit, 1984.

Bjornn, T.C. 1978. Survival, Production and Yield of Trout and Chinook Salmon on the Lemhi River, Idaho. University of Idaho, Bulletin #27. Moscow, Idaho.

Bjornn, T.C. 1969. Federal Aid to Fish Restoration, Annual Completion Report, Salmon and Steelhead Investigation. Idaho Department of Fish and Game. Boise, Idaho.

Cocnnauer, T. 1977. Stream Resource Maintenance Flow Determinations on Idaho Streams. Idaho Department of Fish and Game. Boise, Idaho.

Goodnight, W.H. and T.C. Bjornn. 1971. Fish Production of Two Idaho Streams. Transactions of the American Fisheries Society. No. 4, pp 769-780.

Horton, W.D. 1984. Instream Flow Investigations, Annual Report. Idaho Department of Fish and Game. Boise, Idaho.

Horton, W.D. 1982. Instream Flow Study, Annual Report. Idaho Department of Fish and Game. Boise, Idaho.

Idaho Department of Fish and Game. 1984. Draft Idaho Anadromous Fish Management Plan: 1984-1990. Idaho Department of Fish and Game, Boise, Idaho, USA.

Idaho Department of Water Resources, "Lemhi River, Alturas Lake Creek and Carmen Creek Flow Augmentation Studies", June 1982.

Iriving, J.S., B. Shepard, T.C. Bjornn, N. Horner, and R.R. Ringe. 1983. Fish Resources in the Gospel-Hump area of Central Idaho and potential impacts of forest management activities. Final Report, Intermountain Forest and Range Experiment Station, USDA Forest Service, Moscow, Idaho.

Linsley, R.K. and J.B. Franzini. 1979. Water Resources Engineering. McGraw-Hill Book Co. New York.

Oregon Department of Fish and Wildlife. 1984. Determining Minimum Flow Requirements for Fish.

Parliman, D.J. 1982. Groundwater Quality in Eastcentral Idaho Valleys, Boise, Idaho, U.S. Geological Survey Open-File Report 81-1011, 55 p.

Raymond, H.J. 1980. Effects of dams and impoundments of migrations of juvenile chinook salmon (Oncohynchus tschawytscha) and steelhead (Salmo gairdneri) from the Snake River, 1966-1975. Transactions of the American Fisheries Society 108:505-529.

USACE. 1985. A methodology for estimating fishery benefits for Galloway Dam and Reservoir, Weiser River, Idaho. Review Draft. U.S. Army Corps of Engineers, Walla Walla District. Walla Walla, Washington, USA.

U.S. Army Corps of Engineers. 1985. "Draft Report, Hayden Creek-Bear Valley Creek Dam, Lemhi River Basin, Idaho", Walla Walla District Corps of Engineers.

U.S. Bureau of Reclamation. May 1942. "Report on Lemhi Basin, Idaho", Department of the Interior.

U.S. Bureau of Reclamation. April 1941. "Report on Lemhi Valley Projects, Salmon River Investigation, Idaho", Department of the Interior.

Young, H.W. and W.A. Harenburg. 1973. A Reconnaissance of the Water Resources in the Pahsimeroi River Basin, Idaho: Boise, Idaho, Idaho Department of Water Administration Water Information Bulletin No. 31, 57 p.

APPENDIX A

LEMHI RIVER DIVERSION AND FLOW MEASUREMENT LOCATIONS

TABLE A.1

LEMHI RIVER DIVERSIONS AND MEASUREMENT LOCATIONS

DIVERSION OR TRIBUTARY LTR	NUM	RIVER MILE	TRIBUTARY OR DIVERSION NAME	LOCATION DIV	SEC	T	R	WATER RIGHTS FLOW	PRIORITY	REMARKS AND LOCATION CODES
		0.00	LEMHI R. MOUTH	SE-SE	32	22N	22E			LEMHI RIVER MOUTH
L	1	0.90		NE-SW	5	21N	22E	3.30	1932.00	
		1.20								LOC1
L	2	1.80		NW-NW	9	21N	22E	1.06	1961.00	
L	2B	2.10		NE-NW	9	21N	22E	1.57	1889.00	
TRIB		2.60	KIRTLEY CREEK	SE-NW	9	21N	22E			LOC3
L	2C	3.00		NW-SW	10	21N	22E	1.04	1963.00	
L	3	3.30		NE-SW	10	21N	22E	14.15	1906.00	
L	3B	4.00		SE-SE	10	21N	22E	2.03	1951.00	
		4.70								LOC2
		5.45								LM1
L	3A	5.50		SE-NE	14	21N	22E	3.99	1869.00	
L	4	5.70		NE-SE	14	21N	22E	4.17	1878.00	
		7.07								LOC8
		7.14								LOC7
L	5	7.20		SW-SE	24	21N	22E	5.18	1894.00	CRITICAL DIVERSION
		7.33								LOC4 & LM2
L	6	7.40	TOWN DITCH	SE-SE	24	21N	22E	41.80	1869.00	CRITICAL DIVERSION
		7.42								LOC5
TRIB		8.10	GEERTSON CREEK	NE-SW	30	21N	23E			
L	7	8.30		NE-SW	30	21N	23E	28.04	1869.00	CRITICAL DIVERSION
L	7A	8.32		NE-SW	30	21N	23E	3.52	1889.00	
L	8	8.60		NW-SE	30	21N	23E	1.59	1961.00	
		8.90								LM3
		9.20								LOC9
L	8A	10.50		NW-NW	33	21N	23E	26.07	1878.00	
L	9	10.52		NW-NW	33	21N	23E	20.79	1909.00	
TRIB		10.54	BOHANNON CREEK	NW-NW	33	21N	23E			
L	10	11.30		NW-SE	33	21N	23E	27.16	1880.00	
L	11	12.00		SW-SW	34	21N	23E	5.76	1880.00	
TRIB		12.20	WIMPEY CREEK	NE-NW	3	20N	23E			
L	12	12.40		NE-NW	3	20N	23E	4.16	1880.00	
TRIB		12.50	PRATT & SANDY CKS	NE-NW	3	20N	23E			
L	13	12.80		SE-NW	3	20N	23E	12.72	1880.00	
TRIB		12.82	WITHINGTON CREEK	SE-NW	3	20N	23E			
L	14	13.10		NE-SW	3	20N	23E	2.28	1902.00	LOC10
L	15	13.90		SW-NE	10	20N	23E	6.81	1871.00	
L	16	14.40		SW-SW	11	20N	23E	8.62	1872.00	
L	17	14.70		NW-NW	14	20N	23E	6.70	1872.00	
L	18	15.20		SW-NE	14	20N	23E	0.99	1899.00	
L	18A	15.21		SW-NE	14	20N	23E	0.32	1892.00	

TABLE A.1

LEMHI RIVER DIVERSIONS AND MEASUREMENT LOCATIONS

DIVERSION OR TRIBUTARY		RIVER	TRIBUTARY OR DIVERSION	LOCATION				WATER RIGHTS		REMARKS AND
LTR	NUM	MILE	NAME	DIV	SEC	T	R	FLOW	PRIORITY	LOCATION CODES
L	19	15.70		SE-SE	14	20N	23E	1.30	1961.00	
L	19A	16.60		NE-SW	24	20N	23E	1.17	1963.00	
		16.65								LOC11
L	20	16.70		NW-SE	24	20N	23E	11.64	1888.00	CRITICAL DIVERSION
L	21	17.10		NW-NE	25	20N	23E	5.74	1892.00	
L	22	17.40		SE-NE	25	20N	23E	29.61	1889.00	
L	22A	17.42		SE-NE	25	20N	23E	8.87	1888.00	
TRIB		17.88	KENNEY CREEK	NE-SW	30	20N	24E			
L	23	17.90		NE-SW	30	20N	24E	2.11	1961.00	
		18.30								LOC13
L	24	19.10		SW-SE	31	20N	24E	1.48	1961.00	
L	25	19.30			6	19N	24E	4.90	1909.00	
L	26	19.60		SW-NE	6	19N	24E	2.87	1887.00	
L	27	20.60		SE-NE	7	19N	24E	2.76	1899.00	
L	28	21.20		SW-SW	8	19N	24E	12.38	1888.00	
L	29	21.50		NW-NW	17	19N	24E	9.07	1887.00	
TRIB		21.80	PATTEE CREEK	SE-NW	17	19N	24E			
		22.70								LOC14
L	30	22.80		NW-NW	20	19N	24E	25.07	1886.00	
TRIB		23.00	AGENCY CREEK	SE-NE	20	19N	24E			
L	30A	23.70		SE-SW	20	19N	24E	0.87	1961.00	
L	31B	24.70		SE-SW	29	19N	24E	1.48	1961.00	
TRIB		24.90	MCDEVITT CREEK	NE-NW	32	19N	24E			
		25.00								LOC15
L	31	24.10		SE-NW	29	19N	24E	[illegible].38	1908.00	
		25.60								LOC16
L	31A	25.80		SW-SE	32	19N	24E	8.28	1873.00	CRITICAL DIVERSION
L	32	26.30		SE-NE	5	18N	24E	15.39	1914.00	
L	33	26.30		SE-NE	5	18N	24E	31.58	1895.00	
L	34	26.50		NE-SE	[illegible]	18N	24E	0.68	1961.00	
L	35	27.00		SW-SW	4	18N	24E	[illegible].42	1912.00	
L	35A	27.00		SW-SW	4	18N	24E	[illegible].42	1961.00	
L	36	28.20		SW-SW	[illegible]	18N	24E	[illegible]	1912.00	
L	37	28.20		SW-SW	[illegible]	18N	24E	1.46	1880.00	
L	38	28.20		NW-NW	16	18N	24E	1.45	1875.00	
		28.50								LOC17
L	39	29.80		SE-NE	20	18N	24E	1.36	1875.00	
		29.90								LOC18
L	40	30.00		NW-SW	21	18N	24E	2.47	1875.00	
TRIB		30.30	HAYDEN CREEK	SW-SW	21	18N	24E			
L	41	30.30		SW-SW	21	18N	24E	11.20	1914.00	CRITICAL DIVERSION

TABLE A.1

LEMHI RIVER DIVERSIONS AND MEASUREMENT LOCATIONS

DIVERSION OR TRIBUTARY LTR	NUM	RIVER MILE	TRIBUTARY OR DIVERSION NAME	LOCATION DIV	SEC	T	R	WATER RIGHTS FLOW	PRIORITY	REMARKS AND LOCATION CODES
L	42	30.50		NW-NW	28	18N	24E	3.80	1875.00	
L	42A&B	30.50		NW-NW	28	18N	24E	40.00	1964.00	
		30.80								LOC20 & LM4
L	43	31.90		NW-NW	33	18N	24E	1.35	1961.00	PROBLEM DIVERSION
L	43A	31.90		NW-NW	33	18N	24E	1.50	1961.00	
L	43B	32.20		SW-NW	33	18N	24E	1.10	1961.00	
L	43C	32.50		NW-SW	33	18N	24E	2.76	1875.00	
		33.50								LOC21
TRIB		33.60	YEARIAN CREEK	NE-SW	4	17N	24E			
L	44	33.70		NE-SW	4	17N	24E	1.53	1911.00	PROBLEM DIVERSION
L	45	33.70		NE-SW	4	17N	24E	2.09	1911.00	
L	45A	35.60		NE-SE	10	17N	24E	2.63	1902.00	
L	45B	36.50		NE-NW	14	17N	24E	1.00	1961.00	
L	45C	36.90		SW-NE	14	17N	24E	1.75	1890.00	
L	45D	36.90		SW-NE	14	17N	24E	8.16	1940.00	PROBLEM DIVERSION
		37.10								LOC22
TRIB		37.40	REESE CREEK	NE-SE	14	17N	24E			
L	46	37.70		SE-SE	14	17N	24E	9.68	1889.00	
L	46A	38.10		NE-NW	24	17N	24E	1.90	1892.00	
L	47	39.30		NW-NE	25	17N	24E	6.10	1886.00	
L	48	39.50		NE-NE	25	17N	24E	4.77	1887.00	
		39.50								LOC23
L	49	39.50		NE-NE	25	17N	24E	5.57	1885.00	
L	50	41.40		SE-SW	29	17N	25E	2.60	1919.00	
L	51	41.80		NW-NE	32	17N	25E	1.57	1885.00	
L	51A	42.20		SE-NE	32	17N	25E	3.12	1885.00	
L	52	43.30		NW-SE	33	17N	25E	5.40	1936.00	
L	52A	43.30		NW-SE	33	17N	25E	0.78	1961.00	
L	54	43.60		SW-SE	33	17N	25E	2.48	1888.00	
L	53	43.80		SE-SE	33	17N	25E	0.81	1888.00	
L	57	44.10		SW-NW	3	16N	25E	1.99	1888.00	
L	58	44.10		SW-NW	3	16N	25E	2.22	1888.00	
		44.60								LM5
		44.80								LM6
TRIB		45.00	BIG EIGHTMILE CREEK	SE-SE	3	16N	25E			
L	58A	45.10		NE-NE	10	16N	25E	5.02	1908.00	
L	58B	45.90		NW-NE	11	16N	25E	4.70	1893.00	
EAST CHANNEL										
L	58C	47.10		NE-SW	12	16N	25E	2.84	1895.00	
L	59	47.70		SE-SE	12	16N	25E	2.11	1887.00	
L	60	48.50		SE-NW	18	16N	26E	2.04	1889.00	

TABLE A.1

LEMHI RIVER DIVERSIONS AND MEASUREMENT LOCATIONS

DIVERSION OR TRIBUTARY LTR	NUM	RIVER MILE	TRIBUTARY OR DIVERSION NAME	LOCATION DIV	SEC	T	R	WATER RIGHTS FLOW	PRIORITY	REMARKS AND LOCATION CODES
		48.75								LOC24 (SIDE CHANNEL)
L	61	49.30		SE-SE	18	16N	26E	4.13	1889.00	CRITICAL DIVERSION
L	61A	50.40		SE-NW	20	16N	26E	0.61		
L	62	51.30		NE-SE	20	16N	26E	5.29	1961.00	
L	63	52.30		SE-SE	28	16N	26E	9.12	1918.00	PROBLEM DIVERSION
		52.35								LOC25
WEST CHANNEL (BIG SPRINGS CREEK)										
		48.60								LOC27

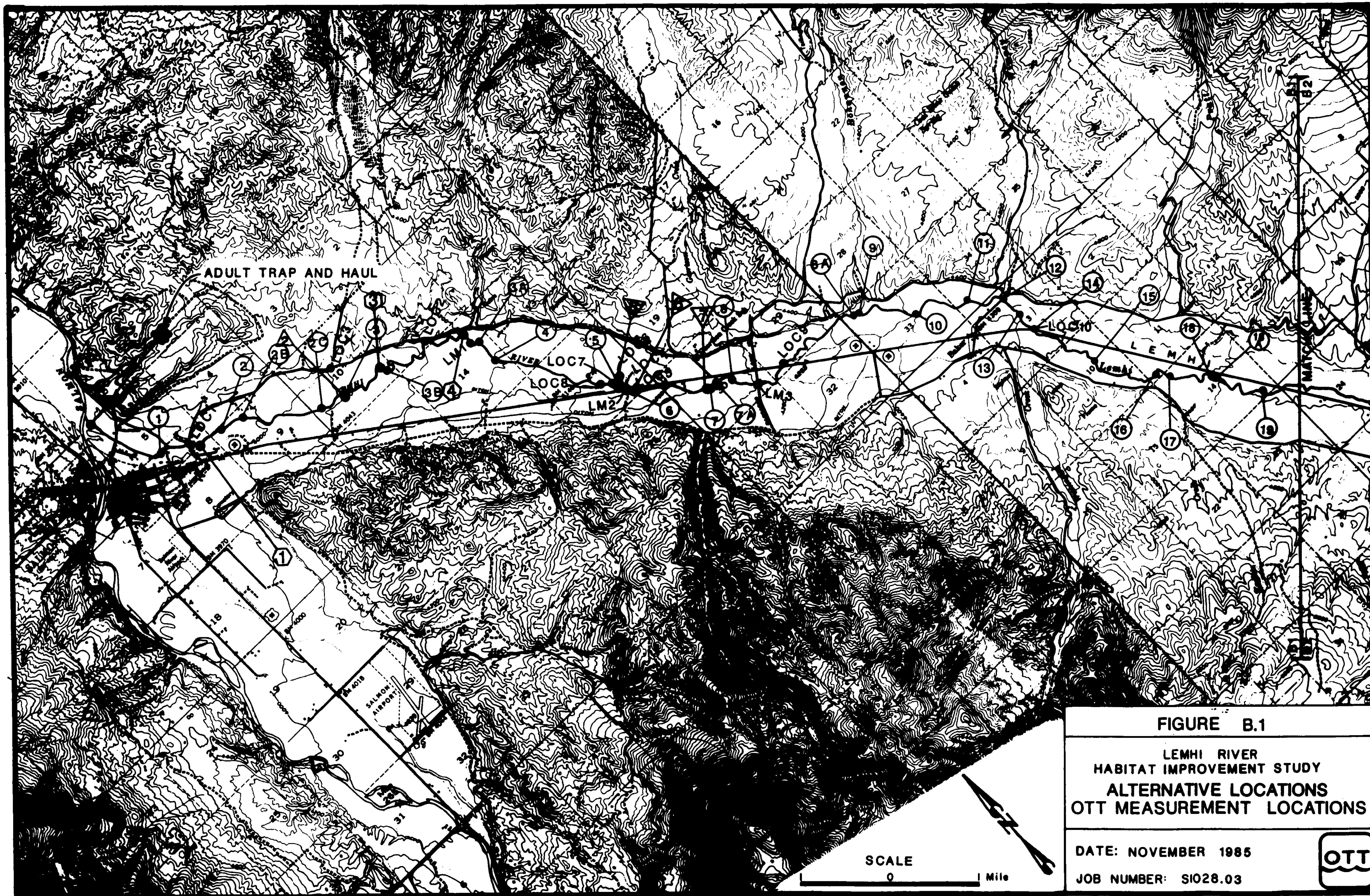


FIGURE B.1

LEMHI RIVER
HABITAT IMPROVEMENT STUDY

ALTERNATIVE LOCATIONS
OTT MEASUREMENT LOCATIONS

DATE: NOVEMBER 1985

JOB NUMBER: SI028.03

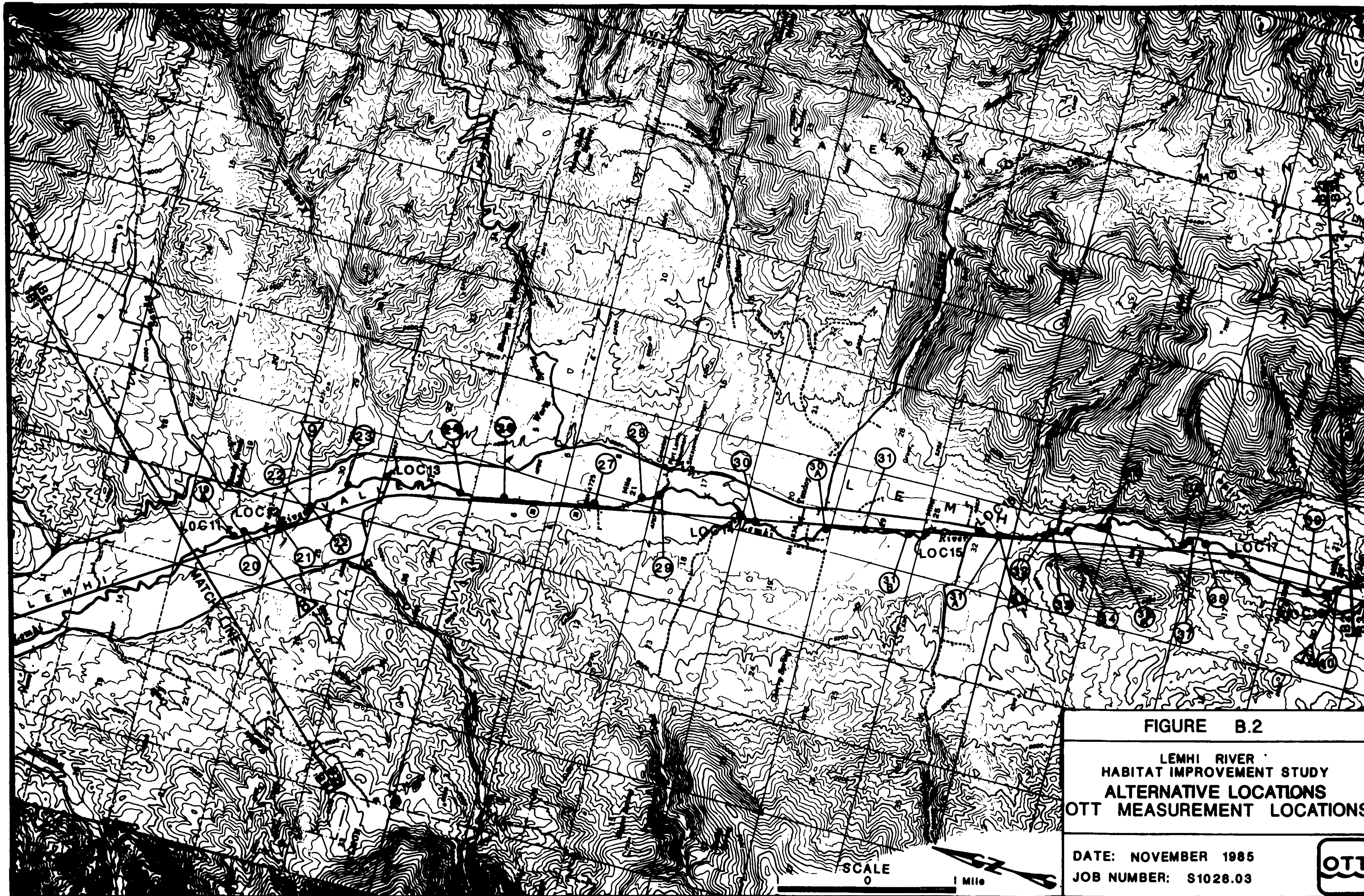


FIGURE B.2

LEMHI RIVER
HABITAT IMPROVEMENT STUDY
ALTERNATIVE LOCATIONS
OTT MEASUREMENT LOCATIONS

DATE: NOVEMBER 1985
JOB NUMBER: S1028.03

OTT

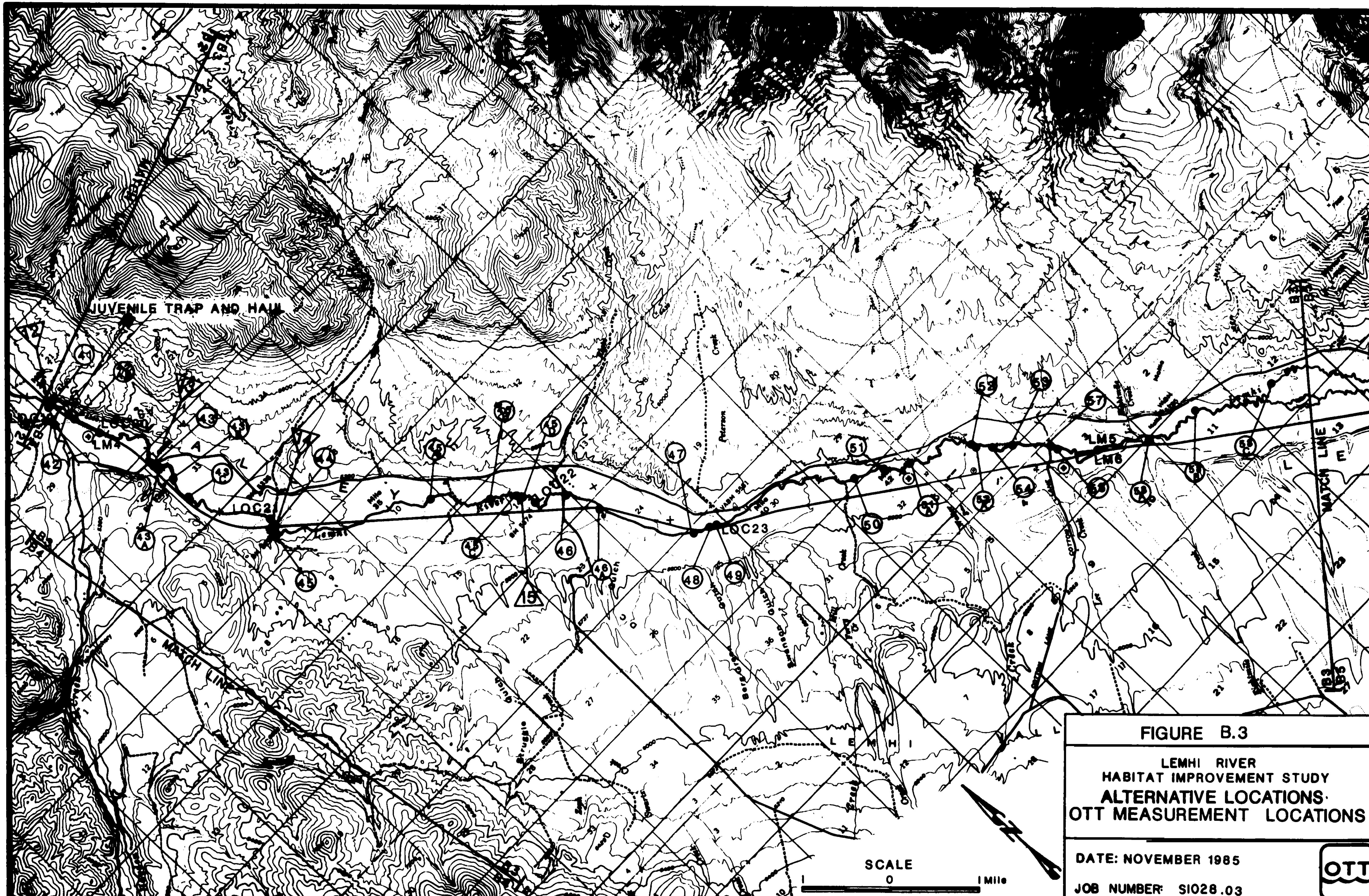


FIGURE B.3

LEMHI RIVER
HABITAT IMPROVEMENT STUDY

ALTERNATIVE LOCATIONS·
OTT MEASUREMENT LOCATIONS

DATE: NOVEMBER 1985

JOB NUMBER: SI028.03

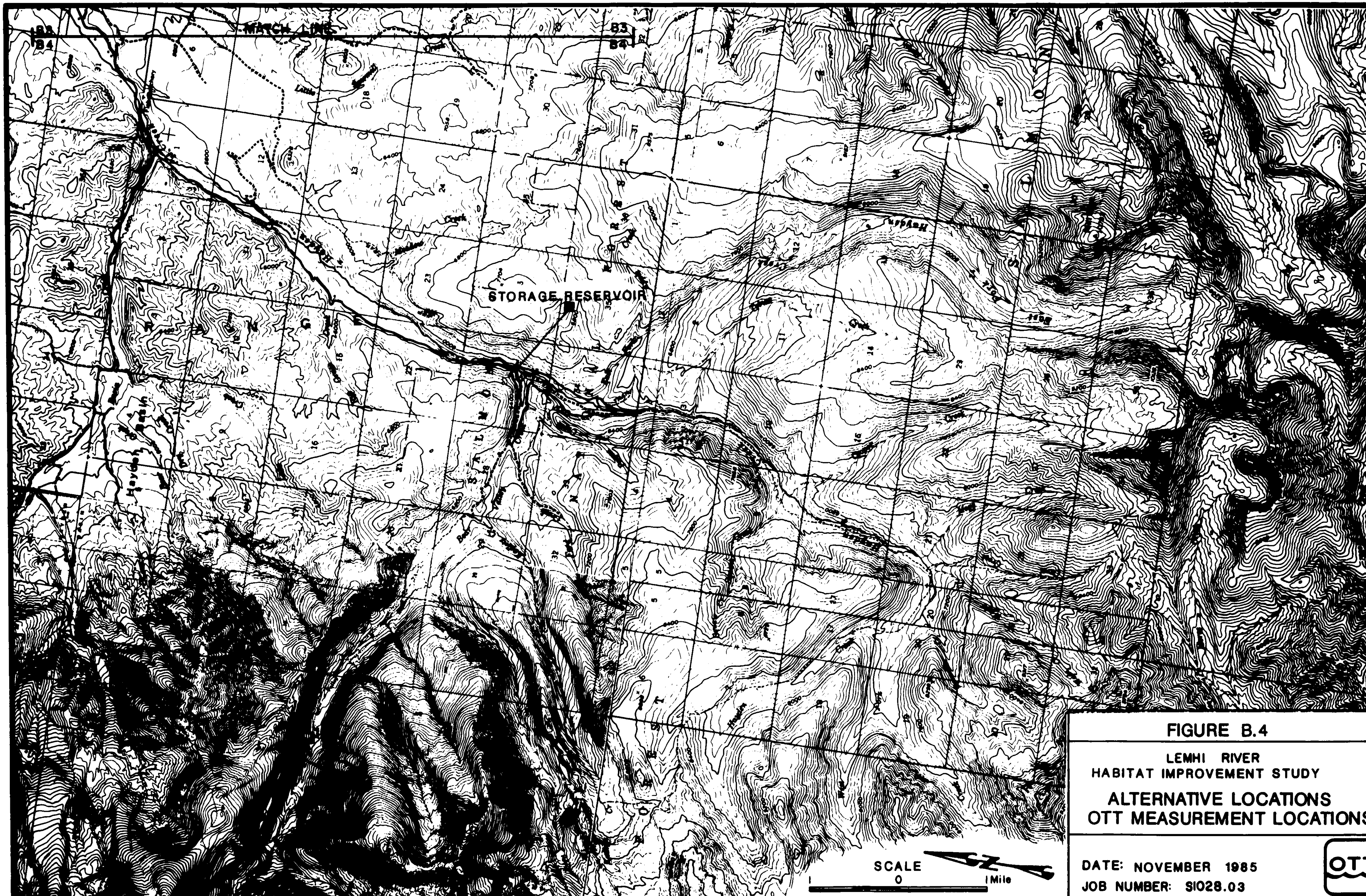


FIGURE B.4

LEMHI RIVER
HABITAT IMPROVEMENT STUDY

ALTERNATIVE LOCATIONS
OTT MEASUREMENT LOCATIONS

DATE: NOVEMBER 1985
JOB NUMBER: S1028.03

OTT

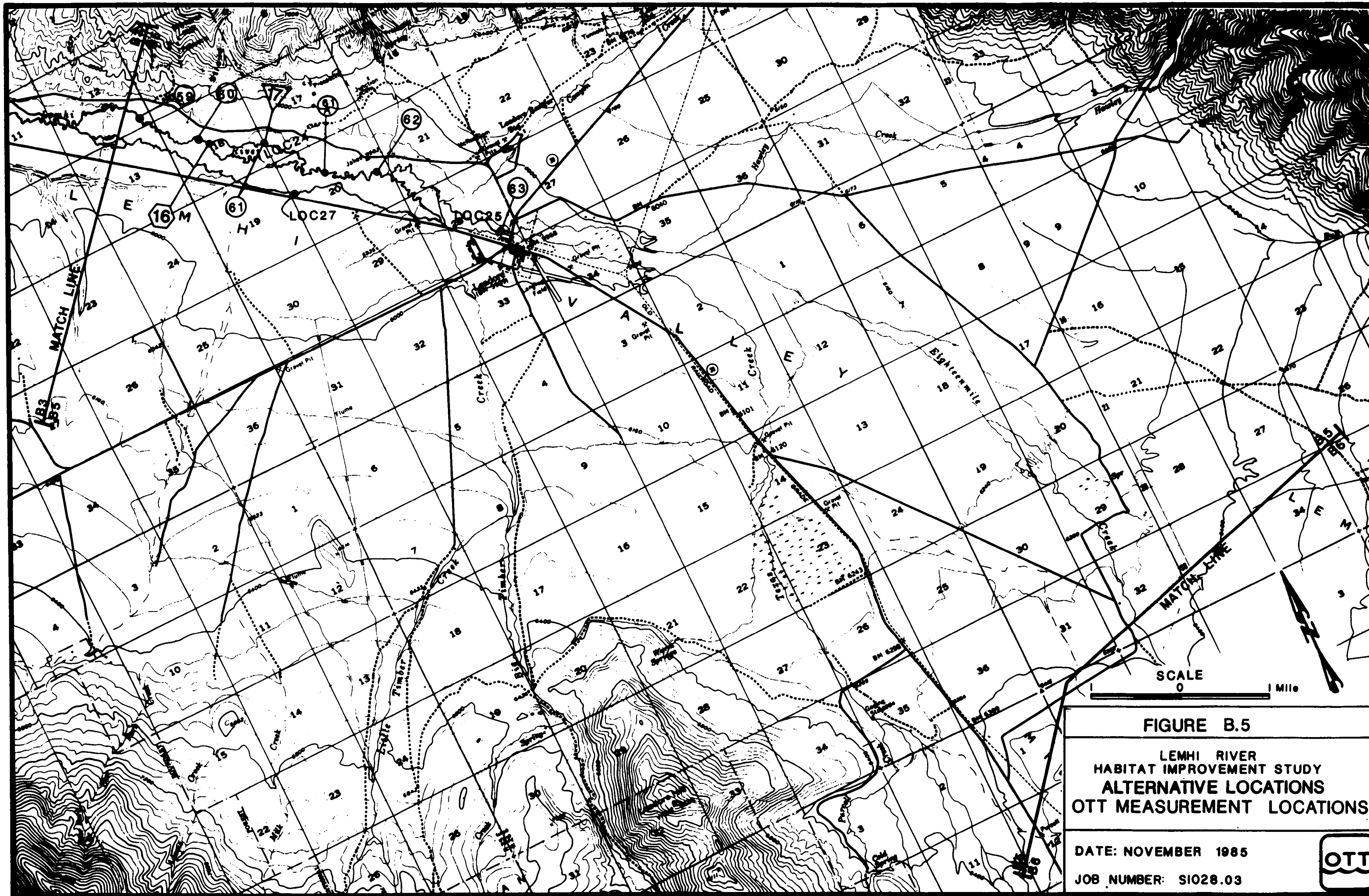


FIGURE B.5

LEMHI RIVER
HABITAT IMPROVEMENT STUDY
ALTERNATIVE LOCATIONS
OTT MEASUREMENT LOCATIONS

DATE: NOVEMBER 1985

JOB NUMBER: S1028.03

OTT

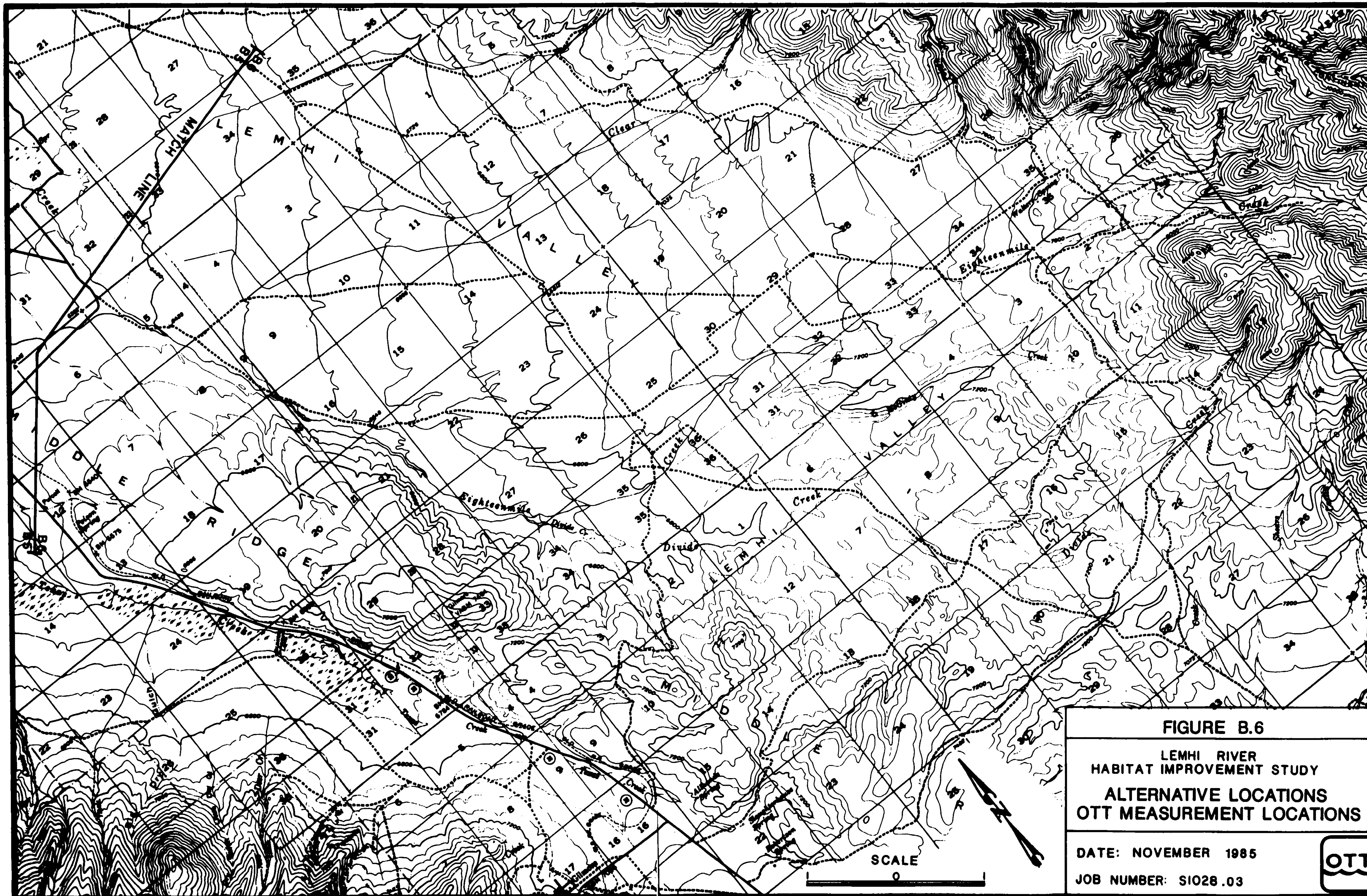


FIGURE B.6

LEMHI RIVER
HABITAT IMPROVEMENT STUDY

ALTERNATIVE LOCATIONS
OTT MEASUREMENT LOCATIONS

DATE: NOVEMBER 1985

JOB NUMBER: S1028.03

OTT

APPENDIX C

ANNOTATED BIBLIOGRAPHY

HYDROLOGY

Bureau of Reclamation. October 1939. 141 Aerial Photographs of the Lemhi Basin. Scale 1:20,000.

Sterographic aerial photographs which may be useful to gain an overview of Basin topography and layout.

Bureau of Reclamation. 1940-194s. Supporting Data for the Lemhi Valley Water Conservation Projects: Leadore, Hawley, Hayden, Yearian, and Agency Creek Projects. Department of the Interior.

Contains supporting hydrologic and topographic data used in Lemhi Basin reports.

Bureau of Reclamation. March 1940. Advance Report on Challis-Lemhi-Pahsimeroi Valleys, Salmon River Investigations, Idaho. Department of the Interior.

Preliminary study to determine the need for more in-depth studies on reservoir sites for irrigation and hydropower. Provides an overview of valley characteristics but no detailed hydrologic data.

Bureau of Reclamation. 1941. Lower Lemhi Project Supporting Data. Department of the Interior.

Data used to evaluate the feasibility of diverting water from Salmon River via a canal, in order to irrigate the lower Lemhi Valley and to generate electricity. Hydrologic data for the Salmon and Lemhi Rivers as well as for diversions near the Town of Salmon.

Bureau of Reclamation. April 1941. Report on Lemhi Valley Projects, Salmon River Investigations, Idaho. Department of the Interior.

Report elaborates on the general characteristics of the Lemhi River Basin such as climate, soils, geology, flood control, drainage, and agriculture. Details are also given on seven possible solutions (reservoir locations) to the problem of dewatering due to irrigation diversions. Project benefits are measured in terms of replacing diverted water and increasing crop yield.

Bureau of Reclamation. May 1942. Report on Lemhi Basin, Idaho. Department of the Interior.

This is an analysis made of similar dam and canal projects in the Lemhi Basin. Estimates and data are presented on existing and storable flow.

Bureau of Reclamation. May 1944. Appendix fcr Report on Lemhi River Basin, Idaho. Department of the Interior.

Contains supporting data used in developing a report on reservoir site alternatives in the Basin, including hydrology, survey notes, and design drawings. Hydrologic data are particularly valuable because of stream flow measurements made on creeks which have never been gaged by the USGS.

Bureau of Reclamation. May 1944. Report on Lemhi River Basin, Idaho. Department of the Interior.

Presents further benefit/cost study on irrigation and hydropower sites for the Lemhi Valley.

Cheney, M.B. 1970. General Soil Map and Interpretations for Broad Resource Planning. U.S. Department of Agriculture, Soil Conservation Service. Lemhi County, Idaho.

General soil characteristics, qualities, and interpretations for both agricultural and nonfarm use. Also contains descriptions of each soil series and limitations for various types of construction such as streets, sewers, etc. Some ASTM compressive and strength details presented.

Cochnauer, T. 1977. Federal Aid in Fish and Wildlife Restoration. Job Performance Report: Stream Flow Investigations. Project No. F-66-R-2, Job Nos. 2, 3, 10, 131, 16, 17.

Results of study on stream resource maintenance flows for various river systems in Idaho, including fish periodicity and preference curves (spawning width versus discharge) for the Lemhi River.

Decker, S.O., Hammond, R.E., L.C. Kjelstrom et al. 1970. Miscellaneous Stream Flow Measurements in Idaho, 1894-1967. U.S. Geological Survey, Resources Division. Boise, Idaho. 1970.

A compilation of stream discharges at miscellaneous sites and peak discharges at partial record stations. This basic data release was prepared by the USGS in coopertion with the Idaho Department of Water Administration.

U.S. Army Corps of Engineers, Walla Walla District, Water Division. 1983. Survey Field Notes of Topography Along the Lemhi River, Vicinity of Salmon, Idaho.

Field notes collected by the Walla Walla Corps District for a study initiated to solve the salmon migration problems in the Lemhi River. The Corps surveyed several cross sections along the lower Lemhi, and examined the possibilities for creating a more defined stream thalwag which would concentrate the flow for anadromous fish.

Idaho Department of Water Resources. 1982. Lemhi River, Alturas Lake Creek, and Carmen Creek Flow Augmentation Studies. Boise, Idaho.

Report develops hydrologic and related data for the Lemhi River and two unrelated creeks. These data were to be used by the Corps of Engineers to study stream flow augmentation as a means of improving fish passage. Low flow areas, timing and magnitude of augmentation needs, and existing stream flow quantities are discussed.

Idaho Department of Water Resources. Well Logs, Basin No. 74, Lemhi River. Boise, Idaho. (Microfiche)

Well logs obtained from the Idaho Department of Water Resources contain information on depth, soil composition, recharge rate, and capacity. Several hundred logs are available, however, a sample of 50 was selected.

Lemhi Irrigation District. Miscellaneous Discharge Measurements for 1981 and 1983.

Matricies were obtained from the Lemhi Irrigation District which tabulate measurements of River and irrigation canal flows. Location and date of measurement are given on these tables. Data were used to estimate return flow from irrigation and groundwater.

National Oceanic and Atmospheric Administration (NOAA), National Climatic Data Center, Climatological Data for Idaho. Ashville, North Carolina.

Climatological data for Salmon, Idaho and surrounding areas. Included are temperature, evaporation, precipitation, wind, humidity, and other parameters for these stations.

Sisco, G. L. 1975. Miscellaneous Discharge Measurements in Idaho, Basin 74, 1964-1974. Idaho Department of Water Resources. Boise, Idaho.

Report contains discharges measured on the Lemhi River and several tributaries during 1964 through 1974.

Soil Conservation Service, Snow Survey Division. 1984. Information on Lemhi River Basin: Diversion Survey Locations and Discharges for 1979-1980.

Data collected by the Lemhi Valley Irrigation District for the SCS to be used in snowmelt runoff estimation studies. Discharge measurements were made for 1979 and 1980 irrigation seasons.

U.S. Army Corps of Engineers, Walla Walla District. 1983. Photographs of Survey of Lemhi River.

Photographs taken by the Walla Walla Corps District during the September 1983 survey of the Lemhi River. Because of the high water during this year, no flow deficiencies are evident from these pictures.

U.S. Department of Agriculture, Soil Conservation Service. Soil Interpretation Records.

Detailed interpretation records for nearly every soil series in the Lemhi Valley. Each sheet tabulates data on texture, depth, permeability, water holding capacity, agricultural capability, etc. for a soil series. These are unpublished records used by the SCS in Salmon, Idaho for design and recommendation purposes.

U.S. Department of Agriculture, Soil Conservation Service. 1962. Land Capability Classification, Agriculture Handbook No. 210 U.S. Government Printing Office.

Provides uniform classification descriptions and applicability of land capability codes which are designated on SCS soil interpretation records.

U.S. Department of Agriculture, Soil Conservation Service. 1981. Soil Survey Map and Legend, Area No. 752.

Map delineates the areas along the Lemhi Valley where the various general soil groups are located. Each area is color coded, numbered, and keyed to a legend which describes the soil series groups.

U.S. Department of Agriculture, Soil Conservation Service. 1983. Sprinkler System Design Data.

Crop data for the Lemhi Basin climatic area and guidelines for designing lateral sprinkler systems.

U.S. Geological Survey. Water Resource Data. Part 13, Snake River Basin.

Miscellaneous gage information for the Lemhi River and tributaries, for various years of record from 1912 to present.

U.S. Geological Survey. Well Logs, Lemhi County, 1976-1983.

These well logs tabulate date, water level, and characteristics for three wells monitored by the USGS in the Lemhi Valley.

WATER RIGHTS AND LEGISLATION

Idaho Legislature, Irrigation and Drainage - Water Rights and Reclamation. Volume 8, Title 43 Idaho Water Law. Boise, Idaho.

Water law in Idaho guiding all aspects of surface, spring, and groundwater diversion and transport.

Idaho Department of Fish and Game. Water Rights Location Map. 1960.

Approximated map developed by IDFG to determine the actual (versus decreed) location of irrigation diversions on the Lemhi.

Proposed Finding of Water Rights in the Lemhi River Basin, Civil Case No. 4948.

Tabulates the adjudicated water rights and priorities of all claimants along the Lemhi River and tributaries. The location, use, and amount of irrigated acreage is also given for each water right.

FISHERIES

Bjornn, T.C. 1969. Federal Aid to Fish Restoration, Annual Completion Report, Salmon and Steelhead Investigations. Project F-49-R-6, Job Nos. 3, 4, 6, 8. Idaho Department of Fish and Game.

Report discusses salmon and steelhead investigations in the Lemhi River and Big Springs Creek, Idaho, from January 1, 1967 to December 31, 1967. Areas of study are production, escapement and harvest, embryo survival and emergence, and temperature effects on spawning and emergence of juvenile salmon and steelhead trout.

Bjornn, T.C. 1969. Federal Aid to Fish Restoration, Job Completion Report, Salmon and Steelhead Investigations. Project F-49-R-7, Job Nos. 2, 3. Idaho Department of Fish and Game.

Completion report explains salmon and steelhead investigations in the Lemhi River and Big Springs Creek, Idaho, from March 1, 1968 to February 28, 1969. Areas of study are production, escapement, and harvest of juvenile salmon and trout.

Bjornn, T.C. 1970. Federal Aid in Fish and Wildlife Restoration, Job Completion Report, Salmon and Steelhead Investigations. Project F-49-R-8, Job Nos. 2, 3. Idaho Department of Fish and Game.

Describes salmon and steelhead investigations in the Lemhi River and Big Springs Creek, Idaho, from March 1, 1969 to February 28, 1970. Study topics are production, yield, and escapement of juvenile salmon and steelhead trout.

Bjornn, T.C. 1971. Trout and Salmon Movements in Two Idaho Streams as Related to Temperature, Food, Stream Flow, Cover, and Population Density. Trans. Amer. Fish. Soc. 100:423-438.

The study addresses factors which might be responsible for the biannual migration of anadromous and nonanadromous fish in the Lemhi River and Big Springs Creek. Water temperature, substrate, vegetation, and stream flow are the variables used.

Bjornn, T.C. 1978. Survival, Production, and Yield of Trout and Chinook Salmon in the Lemhi River, Idaho. Final Report. Project F-49-R. Idaho Department of Fish and Game.

This is the final report for the Federal Aid to Fish Restoration, Salmon and Steelhead Investigations, Project F-49-R. It summarizes studies on the Lemhi River and presents an assessment of the summer and winter capacity of the upper Lemhi River for juvenile chinook salmon and steelhead trout.

Goodnight, W.H., and T.C. Bjornn. 1971. Fish Production in Two Idaho Streams. Trans. Amer. Fish Soc. 100:769-780.

Article is the conclusion of the first part of a long-term study of fish yield and production in Big Springs Creek and the Lemhi River.

Horner, N. and T.C. Bjornn. 1981. Status of Upper Columbia and Snake River Spring Chinook Salmon in Relation to the Endangered Species Act. U.S. Fish and Wildlife Service.

The purpose of the study is to determine whether or not spring chinook salmon should be listed as endangered or threatened' under the Act. Criteria used include:

1. The present or threatened destruction, modification, or curtailment of salmon habitat or ranqe.
2. Problems with over utilization.
3. Occurrence of disease and predation.
4. The inadequacy of existing regulatory mechanisms.
5. Other natural or manmade factors.

Idaho Department of Fish and Game. 1977. Photographs of Dewatered Lemhi River.

These photographs were taken by IDFG showing the dewatering effects of a low water year coupled with high irrigation diversion along the Lemhi River.

Idaho Department of Fish and Game. 1984. Idaho Anadromous Fish Management Plan. Boise, Idaho.

The document presents the proposed goals, policies, and strategies for the production and harvest of anadromous salmon and steelhead for the period 1984 - 1990.

U.S. Department of the Interior, U.S. Bureau of Reclamation, Pacific Northwest Region. July 1984. Idaho Anadromous Fish Habitat Appraisal Report. Boise, Idaho.

Summary of a study by the Bureau of Reclamation to discover a means for improving and increasing spawning and rearing habitat in the Salmon and Clearwater River Basins. Ten streams were evaluated for the potential to produce salmon and/or steelhead, and the associated economic, environmental quality, and social effects caused by developing such potential.

GEOLOGY

Anderson, A.L. 1961. Geology and Mineral Resources of the Lemhi Quandrangle, Lemhi County, Idaho: Idaho Bureau of Mines and Geology Pamphlet 124. Moscow, Idaho.

Pamphlet describes minerals and geology of the Lemhi Basin, and includes a map of these resources. Used in assessing background conditions for an analysis of groundwater return flow.

Young, H.W. and W.A. Harenburg. 1973. A Reconnaissance of the Water Resources in the Pahsimeroi River Basin, Idaho: Idaho Department of Water Administration Water Information Bulletin No. 31. Boise, Idaho.

This publication focuses on groundwater resources in the Pahsimeroi Basin. Because of the similar geologic history and formations in the Lemhi and Pahsimeroi Basins, correlations can be made for analyzing well installation and capactiy in the lower Lemhi Valley.

Parliman, D.J. 1982. Groundwater Quality in Eastcentral Idaho Valleys. Open File Report 81-1011. U.S. Geological Survey.

Report presents a reconnaissance level description of water quality conditions in major aquifers of East-Central Idaho valleys including the Lemhi River Basin. Water quality characteristics determined include specific conductance, pH, water temperature, major dissolved cations, major dissolved anions, and coliform bacteria. Report also contains an assessment of groundwater movement, including a map of the potentiometric surface.

Young, H.W. and R.E. Lewis. 1982. Thermal Springs in the Salmon River Basin, Central Idaho. Open File Report 82-103. U.S. Geological Survey.

A thermal and chemical breakdown of thermal springs in the Salmon River Basin, Idaho. Analysis includes the number and distribution within the Basin, chemical and isotropic composition, and the quantities of heat and water which these springs are presently discharging.

APPENDIX D

HYDROLOGY TABLES AND FIGURES

TABLE D.l

U.S.G.S. STREAM FLOW DATA

Station Number	Station Name	Drainage Area	Period of Record
13303000	Texas Creek near Leadore	71.4	1938-39; 1955-63
13303500	Timber Creek near Leadore	57.0	1912; 1938-39
13304000	West Fork Timber Creek near Leadore	16.5	1912
13304200	Big Springs Creek near Leadore		1950-61
13304500	Eightmile Creek near Leadore	20.0	1912
13305000	Lemhi River near Lemhi	890.0	1938-39; 1955-63; 1967-present
13305500	Lemhi River at Salmon	1270.0	1928-43

TABLE D.2

DAILY PRECIPITATION AND TEMPERATURE DATA

Station Number	Station Name	Drainage Area	Period of Record
5177	Leadore 2	Precipitation only	10/65 - present
8080	Salmon ID	Precipitation and temperature	12/67 - present

TABLE D.3

SNOW SURVEY SITES

Station Name	Elevation (feet)	Period of Record
Above Gilmore	8240	1962 - present
Aspen Hall Pass	8200	1964 - present
Copes Camp	7520	1962 - present
Hall Creek	7650	1964 - present
Meadow Lake	9120	1962 - present
Schwartz Lake	8540	1962 - present

TABLE D.4

MONTHLY FLOW STATISTICS OF THE
LEMHI RIVER NEAR LEMHI*

Month	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Minimum	208	226	197	188	216	224	206	112	232	155	78	115
25th Percentile	242	275	227	232	225	253	247	242	493	220	142	136
Mean	280	298	252	251	256	275	294	358	648	367	180	185
75th.Percentile	317	319	278	277	276	304	305	427	742	412	190	219
Maximum	405	379	339	319	322	330	473	816	1302	909	349	274

*Based on records for water years 1968-84 from gage 13305000.

TABLE D.5

MEAN MONTHLY FLOWS ON HAYDEN CREEK
AND LEMHI RIVER

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Hayden Creek at Mouth	34	45	45	40	40	45	110	170	280	120	35	30
Lemhi River near Lemhi	280	298	252	251	256	275	294	358	648	367	180	185
Ratio	0.13	0.15	0.18	0.16	0.16	0.16	0.37	0.47	0.43	0.33	0.19	0.16

Notes: Hayden Creek data from Bureau of Reclamation

Lemhi River data based on record at gage 13305000 from 1968 through 1984

TABLE D.6

LEMHI RIVER 15-DAY LOW FLOWS

DIVERSION OR TRIBUTARY LTR	NUM	RIVER MILE	TRIBUTARY OR DIVERSION NAME	WATER RIGHTS FLOW	PRIORITY	FLOW MEASUREMENT LOCATION CODES OTT	L.I.D.	SPRING 15-DAY LOW FLOWS BELOW DIVERSION 2-YEAR	10-YEAR	20-YEAR	50-YEAR
L	22	17.40		29.61	1889.00			179.68	106.68	79.68	39.68
L	22A	17.42		8.87	1888.00			204.71	131.71	104.71	64.71
L	23	17.90		2.11	1961.00			208.89	135.89	108.89	68.89
		18.30				LOC13		207.88	134.88	107.88	67.88
L	24	19.10		1.48	1961.00			202.28	129.28	102.28	62.28
L	25	19.30		4.90	1909.00			202.14	129.14	102.14	62.14
L	26	19.60		2.87	1887.00			204.20	131.20	104.20	64.20
L	27	20.60		2.76	1899.00			199.64	126.64	99.64	59.64
L	28	21.20		12.38	1888.00			197.79	124.79	97.79	57.79
L	29	21.50		9.07	1887.00			206.21	133.21	106.21	66.21
		22.70				LOC14		205.52	132.52	105.52	65.52
L	30	22.80		25.07	1886.00			204.82	131.82	104.82	64.82
L	30A	23.70		0.87	1961.00			219.83	146.83	119.83	79.83
L	31	24.10		7.38	1908.00			217.77	144.77	117.77	77.77
L	31B	24.70		1.48	1961.00			219.84	146.84	119.84	79.84
		25.00	U.S.G.S. GAGE					219.00	146.00	119.00	79.00
		25.00				LOC15		219.00	146.00	119.00	79.00
		25.60				LOC16		216.60	143.60	116.60	76.60
L	31A	25.80		8.28	1873.00			215.80	142.80	115.80	75.80
L	32	26.30		15.39	1914.00			220.84	147.84	120.84	80.84
L	33	26.30		31.58	1895.00			233.92	160.92	133.92	93.92
L	34	26.50		0.68	1961.00			259.96	186.96	159.96	119.96
L	35	27.00		2.42	1912.00			258.54	185.54	158.54	118.54
L	35A	27.00		1.42	1961.00			260.60	187.60	160.60	120.60
L	36	28.20		2.82	1912.00			257.00	184.00	157.00	117.00
L	37	28.20		1.46	1880.00			259.40	186.40	159.40	119.40
L	38	28.20		1.45	1875.00			260.64	187.64	160.64	120.64
		28.50				LOC17		260.67	187.68	160.68	120.68
L	39	29.80		1.36	1875.00			255.48	182.48	155.48	115.48
		29.90				LOC18		256.23	183.23	156.23	116.23
L	40	30.00		2.47	1875.00			255.83	182.83	155.83	115.83
HAYDEN CR		30.30				LOC19		256.73	183.73	156.73	116.73
L	41	30.30		11.20	1914.00			256.73	183.73	156.73	116.73
L	42	30.50		3.80	1875.00			265.45	192.45	165.45	125.45
L	42A&B	30.50			1964.00			268.68	195.68	168.68	128.68
		30.80				LOC20	LM4	267.48	194.48	167.48	127.48
L	43	31.90		1.35	1961.00			263.08	190.08	163.08	123.08
L	43A	31.90		1.50	1961.00			264.23	191.23	164.23	124.23
L	43B	32.20		1.10	1961.00			264.30	191.30	164.30	124.30
L	43C	32.50		2.76	1875.00			264.04	191.04	164.04	124.04
		33.50				LOC21		262.38	189.38	162.38	122.38

TABLE D.6

LEMHI RIVER 15-DAY LOW FLOWS

DIVERSION OR TRIBUTARY		RIVER MILE	TRIBUTARY OR DIVERSION NAME	WATER RIGHTS		FLOW MEASUREMENT LOCATION CODES		SPRING 15-DAY LOW FLOWS BELOW DIVERSION			
LTR	NUM			FLOW	PRIORITY	OTT	L.I.D.	2-YEAR	10-YEAR	20-YEAR	50-YEAR
		0.00	LEMHI R. MOUTH	0.00				95.06	22.06	-4.94	-44.94
L	1	0.90		3.30	1932.00			87.86	14.86	-12.14	-52.14
		1.20				LOC1		88.26	15.26	-11.74	-51.74
L	2	1.80		1.06	1961.00			83.46	10.46	-16.54	-56.54
L	2B	2.10		1.57	1889.00			81.96	8.96	-18.04	-58.04
L	2C	3.00		1.04	1963.00			76.10	3.10	-23.90	-63.90
L	3	3.30		14.15	1906.00			74.58	1.58	-25.42	-65.42
L	3B	4.00		2.03	1951.00			81.01	8.01	-18.99	-58.99
		4.70				LOC2		77.14	4.14	-22.86	-62.86
		5.45					LM1	71.14	-1.86	-28.86	-68.86
L	3A	5.50		3.99	1869.00			70.74	-2.26	-29.26	-69.26
L	4	5.70		4.17	1878.00			72.53	-0.47	-27.47	-67.47
		7.07				LOC8		65.11	-7.89	-34.89	-74.89
		7.14				LOC7		64.55	-8.45	-35.45	-75.45
L	5	7.20		5.18	1894.00			64.07	-8.93	-35.93	-75.93
		7.33				LOC4	LM2	67.43	-5.57	-32.57	-72.57
L	6	7.40	ANDREWS DITCH	41.80	1869.00			66.87	-6.13	-33.13	-73.13
		7.42				LOC5		102.24	29.24	2.24	-37.76
L	7	8.30	TOWN DITCH	28.04	1869.00			95.20	22.20	-4.80	-44.80
L	7A	8.32		3.52	1889.00			118.88	45.88	18.88	-21.12
L	8	8.60		1.59	1961.00			119.63	46.63	19.63	-20.37
		8.90					LM3	118.58	45.58	18.58	-21.42
		9.20				LOC9		116.18	43.18	16.18	-23.82
L	8A	10.50		26.07	1878.00			107.08	34.08	7.08	-32.92
L	9	10.52		20.79	1909.00			129.10	56.10	29.10	-10.90
L	10	11.30		27.16	1880.00			141.31	68.31	41.31	1.31
L	11	12.00		5.76	1880.00			159.50	86.50	59.50	19.50
L	12	12.40		4.16	1880.00			161.59	88.60	61.60	21.60
L	13	12.80		12.72	1880.00			162.33	89.33	62.33	22.33
		13.10				LOC10		171.04	98.04	71.04	31.04
L	14	13.10		2.28	1902.00			171.04	98.04	71.04	31.04
L	15	13.90		6.81	1871.00			167.38	94.38	67.38	27.38
L	16	14.40		8.62	1872.00			169.67	96.67	69.67	29.67
L	17	14.70		6.70	1872.00			174.90	101.90	74.90	34.90
L	18	15.20		0.99	1899.00			177.09	104.09	77.09	37.09
L	18A	15.21		0.32	1892.00			177.86	104.86	77.86	37.86
L	19	15.70		1.30	1961.00			174.71	101.71	74.71	34.71
L	19A	16.60		1.17	1963.00			169.51	96.51	69.51	29.51
		16.65				LOC11		170.15	97.15	70.15	30.15
L	20	16.70		11.64	1888.00			169.80	96.80	69.80	29.80
L	21	17.10		5.74	1892.00			176.90	103.90	76.90	36.90

TABLE D.6

LEMHI RIVER 15-DAY LOW FLOWS

DIVERSION OR TRIBUTARY LTR	NUM	RIVER MILE	TRIBUTARY OR DIVERSION NAME	WATER RIGHTS FLOW	PRIORITY	FLOW MEASUREMENT LOCATION CODES OTT	L.I.D.	SPRING 15-DAY LOW FLOWS BELOW DIVERSION 2-YEAR	10-YEAR	20-YEAR	50-YEAR
L	44	33.70		1.53	1911.00			261.58	188.58	161.58	121.58
L	45	33.70		2.09	1911.00			262.88	189.88	162.88	122.88
L	45A	35.60		2.63	1902.00			257.06	184.06	157.06	117.06
L	45B	36.50		1.00	1961.00			255.70	182.70	155.70	115.70
L	45C	36.90		1.75	1890.00			254.95	181.95	154.95	114.95
L	45D	36.90		8.16	1940.00			256.43	183.43	156.43	116.43
		37.10				LOC22		262.57	189.57	162.57	122.57
L	46	37.70		9.68	1889.00			260.17	187.17	160.17	120.17
L	46A	38.10		1.90	1892.00			266.80	193.80	166.80	126.80
L	47	39.30		6.10	1886.00			263.61	190.61	163.61	123.61
L	48	39.50		4.77	1887.00			268.00	195.00	168.00	128.00
		39.50				LOC23		272.05	199.05	172.05	132.05
L	49	39.50		5.57	1885.00			272.05	199.05	172.05	132.05
L	50	41.40		2.60	1919.00			269.19	196.19	169.19	129.19
L	51	41.80		1.57	1885.00			269.80	196.80	169.80	129.80
L	51A	42.20		3.12	1885.00			269.53	196.53	169.53	129.53
L	52	43.30		5.40	1936.00			267.78	194.78	167.78	127.78
L	52A	43.30		0.78	1961.00			272.37	199.37	172.37	132.37
L	54	43.60		2.48	1888.00			271.84	198.84	171.84	131.84
L	53	43.80		0.81	1888.00			273.14	200.14	173.14	133.14
L	57	44.10		1.99	1888.00			272.63	199.63	172.63	132.63
L	58	44.10		2.22	1888.00			274.32	201.32	174.32	134.32
		44.60					LM5	274.21	201.21	174.21	134.21
		44.80					LM6	273.41	200.41	173.41	133.41
L	58A	45.10		5.02	1908.00			272.21	199.21	172.21	132.21
L	58B	45.90		4.70	1893.00			273.28	200.28	173.28	133.28
EAST CHANNEL											
L	58C	47.10		2.84	1895.00			149.86	109.71	94.86	72.86
L	59	47.70		2.11	1887.00			149.87	109.72	94.87	72.87
L	60	48.50		2.04	1889.00			148.47	108.32	93.47	71.47
L	61	49.30		4.13	1889.00			147.00	106.85	92.00	70.00
L	61A	50.40		0.61				146.11	105.96	91.11	69.11
L	62	51.30		5.29	1961.00			143.03	102.88	88.03	66.03
L	63	52.30		9.12	1918.00			143.53	103.38	88.53	66.53
		52.35				LOC25		151.08	110.93	96.08	74.08
WEST CHANNEL (BIG SPRINGS CREEK)											
		48.60				LOC27					

TABLE D.7

LEMHI RIVER 15-DAY LOW FLOWS

DIVERSION OR TRIBUTARY LTR	NUM	RIVER MILE	TRIBUTARY OR DIVERSION NAME	WATER RIGHTS FLOW	PRIORITY	FLOW MEASUREMENT LOCATION CODES OTT	L.I.D.	SUMMER 15-DAY LOW FLOWS BELOW DIVERSION 2-YEAR	10-YEAR	20-YEAR	50-YEAR
		0.00	LEMHI R. MOUTH	0.00				87.23	50.23	40.23	28.23
L	1	0.90		3.30	1932.00			76.88	39.88	29.88	17.88
		1.20				LOC1		76.73	39.73	29.73	17.73
L	2	1.80		1.06	1961.00			69.83	32.83	22.83	10.83
L	2B	2.10		1.57	1889.00			67.44	30.44	20.44	8.44
L	2C	3.00		1.04	1963.00			58.66	21.66	11.66	-0.34
L	3	3.30		14.15	1906.00			56.25	19.25	9.25	-2.75
L	3B	4.00		2.03	1951.00			62.35	25.35	15.35	3.35
		4.70				LOC2		56.33	19.33	9.33	-2.67
		5.45					LM1	47.71	10.71	0.71	-11.29
L	3A	5.50		3.99	1869.00			47.13	10.13	0.13	-11.87
L	4	5.70		4.17	1878.00			48.82	11.82	1.82	-10.18
		7.07				LOC8		37.24	0.24	-9.76	-21.76
		7.14				LOC7		36.43	-0.57	-10.57	-22.57
L	5	7.20		5.18	1894.00			35.74	-1.26	-11.26	-23.26
		7.33				LOC4	LM2	39.43	2.43	-7.57	-19.57
L	6	7.40	ANDREWS DITCH	41.80	1869.00			38.62	1.62	-8.38	-20.38
		7.42				LOC5		80.19	43.19	33.19	21.19
L	7	8.30	TOWN DITCH	28.04	1869.00			70.07	33.07	23.07	11.07
L	7A	8.32		3.52	1889.00			97.88	60.88	50.88	38.88
L	8	8.60		1.59	1961.00			98.18	61.18	51.18	39.18
		8.90					LM3	96.32	59.32	49.32	37.32
		9.20				LOC9		92.12	55.12	45.12	33.12
L	8A	10.50		26.07	1878.00			73.92	36.92	26.92	14.92
L	9	10.52		20.79	1909.00			99.71	62.71	52.71	40.71
L	10	11.30		27.16	1880.00			109.58	72.58	62.58	50.58
L	11	12.00		5.76	1880.00			126.94	89.94	79.94	67.94
L	12	12.40		4.16	1880.00			127.10	90.10	80.10	68.10
L	13	12.80		12.72	1880.00			125.66	88.66	78.66	66.66
		13.10				LOC10		134.18	97.18	87.18	75.18
L	14	13.10		2.28	1902.00			134.18	97.18	87.18	75.18
L	15	13.90		6.81	1871.00			125.26	88.26	78.26	66.26
L	16	14.40		8.62	1872.00			125.07	88.07	78.07	66.07
L	17	14.70		6.70	1872.00			129.49	92.49	82.49	70.49
L	18	15.20		0.99	1899.00			129.19	92.19	82.19	70.19
L	18A	15.21		0.32	1892.00			130.04	93.04	83.04	71.04
L	19	15.70		1.30	1961.00			123.50	86.50	76.50	64.50
L	19A	16.60		1.17	1963.00			112.20	75.20	65.20	53.20
		16.65				LOC11		112.67	75.67	65.67	53.67
L	20	16.70		11.64	1888.00			111.97	74.97	64.97	52.97
L	21	17.10		5.74	1892.00			118.01	81.01	71.01	59.01

TABLE D.7

LEMHI RIVER 15-DAY LOW FLOWS

DIVERSION OR TRIBUTARY		RIVER	TRIBUTARY OR DIVERSION	WATER RIGHTS		FLOW MEASUREMENT LOCATION CODES		SUMMER 15-DAY LOW FLOWS BELOW DIVERSION			
LTR	NUM	MILE	NAME	FLOW	PRIORITY	OTT	L.I.D.	2-YEAR	10-YEAR	20-YEAR	50-YEAR
L	22	17.40		29.61	1889.00			119.55	82.55	72.55	60.55
L	22A	17.42		8.87	1888.00			148.88	111.88	101.88	89.88
L	23	17.90		2.11	1961.00			151.03	114.03	104.03	92.03
		18.30				LOC13		147.54	110.54	100.54	88.54
L	24	19.10		1.48	1961.00			136.34	99.34	89.34	77.34
L	25	19.30		4.90	1909.00			135.02	98.02	88.02	76.02
L	26	19.60		2.87	1887.00			135.72	98.72	88.72	76.72
L	27	20.60		2.76	1899.00			124.59	87.59	77.59	65.59
L	28	21.20		12.38	1888.00			118.95	81.95	71.95	59.95
L	29	21.50		9.07	1887.00			127.13	90.13	80.13	68.13
		22.70				LOC14		119.40	82.40	72.40	60.40
L	30	22.80		25.07	1886.00			118.00	81.00	71.00	59.00
L	30A	23.70		0.87	1961.00			130.47	93.47	83.47	71.47
L	31	24.10		7.38	1908.00			125.74	88.74	78.74	66.74
L	31B	24.70		1.48	1961.00			124.72	87.72	77.72	65.72
		25.00	U.S.G.S. GAGE					122.00	85.00	75.00	63.00
		25.00				LOC15		122.00	85.00	75.00	63.00
		25.60				LOC16		118.10	81.10	71.10	59.10
L	31A	25.80		8.28	1873.00			116.80	79.80	69.80	57.80
L	32	26.30		15.39	1914.00			121.83	84.83	74.83	62.83
L	33	26.30		31.58	1895.00			137.22	100.22	90.22	78.22
L	34	26.50		0.68	1961.00			167.50	130.50	120.50	108.50
L	35	27.00		2.42	1912.00			164.93	127.93	117.93	105.93
L	35A	27.00		1.42	1961.00			167.35	130.35	120.35	108.35
L	36	28.20		2.82	1912.00			160.97	123.97	113.97	101.97
L	37	28.20		1.46	1880.00			163.79	126.79	116.79	104.79
L	38	28.20		1.45	1875.00			165.25	128.25	118.25	106.25
		28.50				LOC17		164.75	127.75	117.75	105.75
L	39	29.80		1.36	1875.00			156.30	119.30	109.30	97.30
		29.90				LOC18		157.01	120.01	110.01	98.01
L	40	30.00		2.47	1875.00			156.36	119.36	109.36	97.36
HAYDEN CR		30.30				LOC19		50.88	49.88	48.88	44.88
L	41	30.30		11.20	1914.00			50.88	49.88	48.88	44.88
L	42	30.50		3.80	1875.00			60.78	59.78	58.78	54.78
L	42A&B	30.50			1964.00			64.58	63.58	62.58	58.58
		30.80				LOC20	LM4	62.63	61.63	60.63	56.63
L	43	31.90		1.35	1961.00			55.48	54.48	53.48	49.48
L	43A	31.90		1.50	1961.00			56.83	55.83	54.83	50.83
L	43B	32.20		1.10	1961.00			56.38	55.38	54.38	50.38
L	43C	32.50		2.76	1875.00			55.53	54.53	53.53	49.53
		33.50				LOC21		54.29	53.29	52.29	48.29

TABLE D.7

LEMHI RIVER 15-DAY LOW FLOWS

DIVERSION OR TRIBUTARY LTR	NUM	RIVER MILE	TRIBUTARY OR DIVERSION NAME	WATER RIGHTS FLOW	PRIORITY	FLOW MEASUREMENT LOCATION CODES OTT	L.I.D.	SUMMER 15-DAY LOW FLOWS BELOW DIVERSION 2-YEAR	10-YEAR	20-YEAR	50-YEAR
L	44	33.70		1.53	1911.00			53.49	52.49	51.49	47.49
L	45	33.70		2.09	1911.00			55.02	54.02	53.02	49.02
L	45A	35.60		2.63	1902.00			49.51	48.51	47.51	43.51
L	45B	36.50		1.00	1961.00			48.54	47.54	46.54	42.54
L	45C	36.90		1.75	1890.00			47.94	46.94	45.94	41.94
L	45D	36.90		8.16	1940.00			49.69	48.69	47.69	43.69
		37.10				LOC22		57.05	56.05	55.05	51.05
L	46	37.70		9.68	1889.00			54.65	53.65	52.65	48.65
L	46A	38.10		1.90	1892.00			62.73	61.73	60.73	56.73
L	47	39.30		6.10	1886.00			59.83	58.83	57.83	53.83
L	48	39.50		4.77	1887.00			65.13	64.13	63.13	59.13
		39.50				LOC23		69.90	68.90	67.90	63.90
L	49	39.50		5.57	1885.00			69.90	68.90	67.90	63.90
L	50	41.40		2.60	1919.00			60.27	59.27	58.27	54.27
L	51	41.80		1.57	1885.00			59.67	58.67	57.67	53.67
L	51A	42.20		3.12	1885.00			58.04	57.04	56.04	52.04
L	52	43.30		5.40	1936.00			52.36	51.36	50.36	46.36
L	52A	43.30		0.78	1961.00			57.76	56.76	55.76	51.76
L	54	43.60		2.48	1888.00			56.14	55.14	54.14	50.14
L	53	43.80		0.81	1888.00			57.02	56.02	55.02	51.02
L	57	44.10		1.99	1888.00			55.43	54.43	53.43	49.43
L	58	44.10		2.22	1888.00			57.42	56.42	55.42	51.42
		44.60					LM5	55.64	54.64	53.64	49.64
		44.80					LM6	54.04	53.04	52.04	48.04
L	58A	45.10		5.02	1908.00			51.64	50.64	49.64	45.64
L	58B	45.90		4.70	1893.00			50.26	49.26	48.26	44.26
EAST CHANNEL											
L	58C	47.10		2.84	1895.00			26.27	25.72	25.17	22.97
L	59	47.70		2.11	1887.00			25.51	24.96	24.41	22.21
L	60	48.50		2.04	1889.00			22.82	22.27	21.72	19.52
L	61	49.30		4.13	1889.00			20.06	19.51	18.96	16.76
L	61A	50.40		0.61				17.59	17.04	16.49	14.29
L	62	51.30		5.29	1961.00			12.80	12.25	11.70	9.50
L	63	52.30		9.12	1918.00			12.09	11.54	10.99	8.79
		52.35				LOC25		20.91	20.36	19.81	17.61
WEST CHANNEL (BIG SPRINGS CREEK)											
		48.60				LOC27					

TABLE D.8

LEMHI RIVER MEAN 15-DAY LOW FLOWS

DIVERSION OR TRIBUTARY		RIVER	TRIBUTARY OR DIVERSION	WATER RIGHTS		FLOW MEASUREMENT LOCATION CODES		FLOW BELOW DIVERSIONS		FLOW BETWEEN DIVERSIONS	
LTR	NUM	MILE	NAME	FLOW	PRIORITY	OTT	L.I.D.	SUMMER	SPRING	SUMMER	SPRING
		0.00	LEMHI R. MOUTH	0.00				101.98	90.36		
L	1	0.90		3.30	1932.00			91.63	83.16	96.81	86.76
L	2	1.80		1.06	1961.00			84.58	78.76	89.76	82.61
L	2B	2.10		1.57	1889.00			82.19	77.26	83.92	78.54
L	2C	3.00		1.04	1963.00			73.41	71.40	78.59	75.12
L	3	3.30		14.15	1906.00			71.00	69.88	72.73	71.16
L	3B	4.00		2.03	1951.00			77.10	76.31	81.13	80.17
L	3A	5.50		3.99	1869.00			61.88	66.04	70.51	72.19
L	4	5.70		4.17	1878.00			63.57	67.83	64.72	68.93
L	5	7.20		5.18	1894.00			50.49	59.37	59.12	65.68
L	6	7.40	ANDREWS DITCH	41.80	1869.00			53.37	62.17	54.52	63.36
L	7	8.30	TOWN DITCH	28.04	1869.00			84.82	90.50	90.00	97.24
L	7A	8.32		3.52	1889.00			112.63	114.18	112.75	116.36
L	8	8.60		1.59	1961.00			112.93	114.93	114.54	116.31
L	8A	10.50		26.07	1878.00			87.92	101.08	101.22	108.80
L	9	10.52		20.79	1909.00			113.71	123.10	113.85	125.13
L	10	11.30		27.16	1880.00			123.58	135.31	129.04	139.60
L	11	12.00		5.76	1880.00			140.94	153.50	145.84	157.99
L	12	12.40		4.16	1880.00			141.10	155.59	143.90	157.43
L	13	12.80		12.72	1880.00			139.66	156.33	142.46	158.04
L	14	13.10		2.28	1902.00			148.18	165.04	150.28	167.05
L	15	13.90		6.81	1871.00			139.26	161.38	144.86	164.35
L	16	14.40		8.62	1872.00			139.07	163.67	142.57	165.93
L	17	14.70		6.70	1872.00			143.49	168.90	145.59	170.59
L	18	15.20		0.99	1899.00			143.19	171.09	146.69	173.34
L	18A	15.21		0.32	1892.00			144.04	171.86	144.11	171.97
L	19	15.70		1.30	1961.00			137.50	168.71	140.93	170.44
L	19A	16.60		1.17	1963.00			126.20	163.51	132.50	166.76
L	20	16.70		11.64	1888.00			125.97	163.80	126.67	164.24
L	21	17.10		5.74	1892.00			132.01	170.90	134.81	173.17
L	22	17.40		29.61	1889.00			133.55	173.68	135.65	175.16
L	22A	17.42		8.87	1888.00			162.88	198.71	163.02	201.00
L	23	17.90		2.11	1961.00			165.03	202.89	168.39	205.23
L	24	19.10		1.48	1961.00			150.34	196.28	158.74	200.64
L	25	19.30		4.90	1909.00			149.02	196.14	150.42	196.95
L	26	19.60		2.87	1887.00			149.72	198.20	151.82	199.62
L	27	20.60		2.76	1899.00			138.59	193.64	145.59	197.36
L	28	21.20		12.38	1888.00			132.95	191.79	137.15	194.09
L	29	21.50		9.07	1887.00			141.13	200.21	143.23	202.19
L	30	22.80		25.07	1886.00			132.00	198.82	141.10	204.05
L	30A	23.70		0.87	1961.00			144.47	213.83	150.77	218.86

TABLE D.8

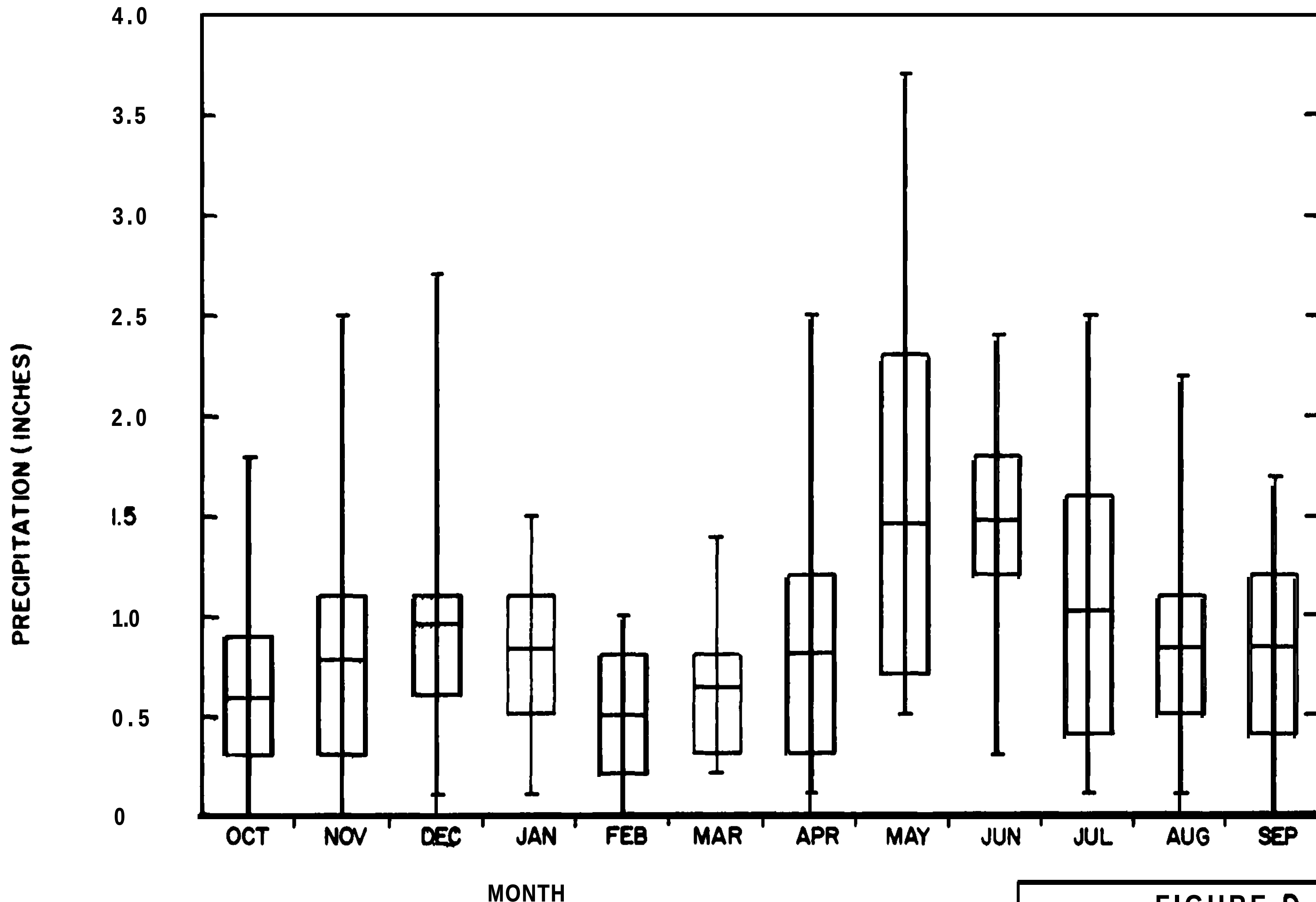
LEMHI RIVER MEAN 15-DAY LOW FLOWS

DIVERSION OR TRIBUTARY LTR	NUM	RIVER MILE	TRIBUTARY OR DIVERSION NAME	WATER RIGHTS FLOW	WATER RIGHTS PRIORITY	FLOW MEASUREMENT LOCATION CODES OTT	FLOW MEASUREMENT LOCATION CODES L.I.D.	FLOW BELOW DIVERSIONS SUMMER	FLOW BELOW DIVERSIONS SPRING	FLOW BETWEEN DIVERSIONS SUMMER	FLOW BETWEEN DIVERSIONS SPRING
L	31	24.10		7.38	1908.00			139.74	211.77	142.54	213.23
L	31B	24.70		1.48	1961.00			138.72	213.84	142.92	216.50
		25.00	U.S.G.S. GAGE					136.00	213.00	138.10	214.16
L	31A	25.80		8.28	1873.00			130.80	209.80	133.40	211.40
L	32	26.30		15.39	1914.00			135.83	214.84	137.46	216.46
L	33	26.30		31.58	1895.00			151.22	227.92	151.22	229.07
L	34	26.50		0.68	1961.00			181.50	253.96	182.15	256.73
L	35	27.00		2.42	1912.00			178.93	252.54	180.56	253.59
L	35A	27.00		1.42	1961.00			181.35	254.60	181.35	254.78
L	36	28.20		2.82	1912.00			174.97	251.00	178.87	253.51
L	37	28.20		1.46	1880.00			177.79	253.40	177.79	253.61
L	38	28.20		1.45	1875.00			179.25	254.64	179.25	254.75
L	39	29.80		1.36	1875.00			170.30	249.48	175.50	252.78
L	40	30.00		2.47	1875.00			170.36	249.83	171.01	250.33
HAYDEN CR		30.30						58.88	116.73		
L	41	30.30		11.20	1914.00			58.88	116.73	58.88	116.73
L	42	30.50		3.80	1875.00			68.78	125.45	69.43	126.69
L	42A&B	30.50			1964.00			72.58	128.68	72.58	128.97
L	43	31.90		1.35	1961.00			63.48	123.08	68.03	125.88
L	43A	31.90		1.50	1961.00			64.83	124.23	64.83	124.33
L	43B	32.20		1.10	1961.00			64.38	124.30	65.35	125.02
L	43C	32.50		2.76	1875.00			63.53	124.04	64.50	124.72
L	44	33.70		1.53	1911.00			61.49	121.58	63.89	124.19
L	45	33.70		2.09	1911.00			63.02	122.88	63.02	123.00
L	45A	35.60		2.63	1902.00			57.51	117.06	61.31	121.02
L	45B	36.50		1.00	1961.00			56.54	115.70	58.34	117.69
L	45C	36.90		1.75	1890.00			55.94	114.95	56.74	115.82
L	45D	36.90		8.16	1940.00			57.69	116.43	57.69	116.57
L	46	37.70		9.68	1889.00			62.65	120.17	64.25	122.38
L	46A	38.10		1.90	1892.00			70.73	126.80	71.53	128.32
L	47	39.30		6.10	1886.00			67.83	123.61	70.23	126.16
L	48	39.50		4.77	1887.00			73.13	128.00	73.53	128.86
L	49	39.50		5.57	1885.00			77.90	132.05	77.90	132.41
L	50	41.40		2.60	1919.00			68.27	129.19	75.87	133.40
L	51	41.80		1.57	1885.00			67.67	129.80	69.27	130.79
L	51A	42.20		3.12	1885.00			66.04	129.53	67.64	130.45
L	52	43.30		5.40	1936.00			60.36	127.78	64.76	130.22
L	52A	43.30		0.78	1961.00			65.76	132.37	65.76	132.78
L	54	43.60		2.48	1888.00			64.14	131.84	65.34	132.50
L	53	43.80		0.81	1888.00			65.02	133.14	65.82	133.73
L	57	44.10		1.99	1888.00			63.43	132.63	64.63	133.29

TABLE D.8

LEMHI RIVER MEAN 15-DAY LOW FLOWS

DIVERSION OR TRIBUTARY		RIVER	TRIBUTARY OR DIVERSION	WATER RIGHTS		FLOW MEASUREMENT LOCATION CODES		FLOW BELOW DIVERSIONS		FLOW BETWEEN DIVERSIONS	
LTR	NUM	MILE	NAME	FLOW	PRIORITY	OTT	L.I.D.	SUMMER	SPRING	SUMMER	SPRING
L	58	44.10		2.22	1888.00			65.42	134.32	65.42	134.47
L	58A	45.10		5.02	1908.00			59.64	132.21	63.64	134.38
L	58B	45.90		4.70	1893.00			58.26	133.28	61.46	135.26
EAST CHANNEL											
L	58C	47.10		2.84	1895.00			30.67	72.86		
L	59	47.70		2.11	1887.00			29.91	72.87	31.71	74.29
L	60	48.50		2.04	1889.00			27.22	71.47	29.62	73.23
L	61	49.30		4.13	1889.00			24.46	70.00	26.86	71.75
L	61A	50.40		0.61				21.99	69.11	25.29	71.62
L	62	51.30		5.29	1961.00			17.20	66.03	19.90	67.88
L	63	52.30		9.12	1918.00			16.49	66.53	19.49	68.92
		52.35						25.31	74.08	25.46	74.86



* SALMON, IDAHO (GAGE 8080 1969-83)

FIGURE D.1

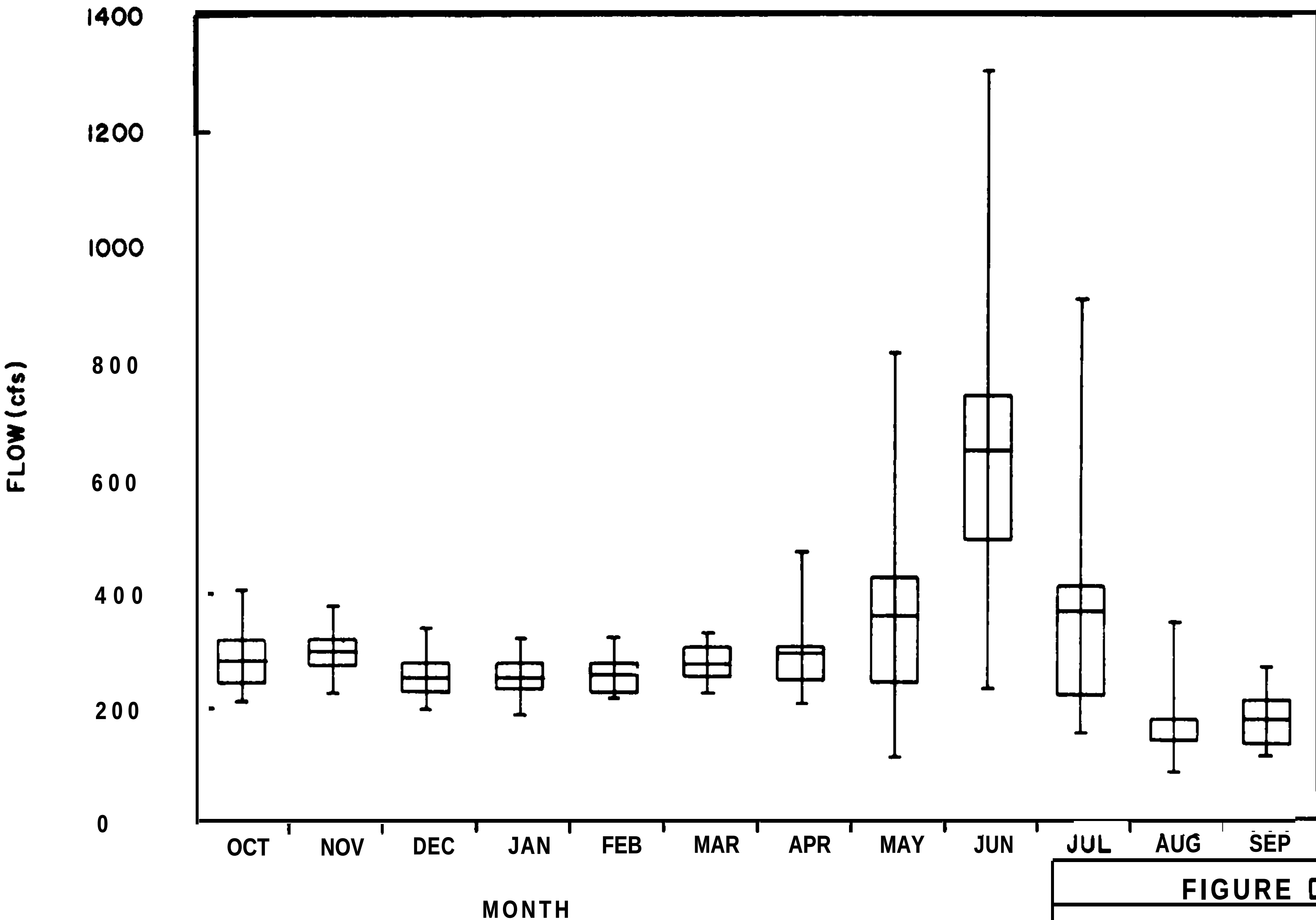
LEMHI RIVER
HABITAT IMPROVEMENT STUDY

MEAN, QUARTILES AND RANGE OF MONTHLY PRECIPITATION

DATE: NOVEMBER 1985

JOB NUMBER: S 1028.03

OTT



* NEAR LEMHI, IDAHO (USGS GAGE 13305000 1968-84)

FIGURE D. 2

LEMH I RIVER
HABITAT IMPROVEMENT STUDY

MEAN, QUARTILES AND RANGE OF MONTHLY FLOWS LEMHI RIVER

DATE: NOVEMBER 1985

JOB NUMBER: S 1028.03

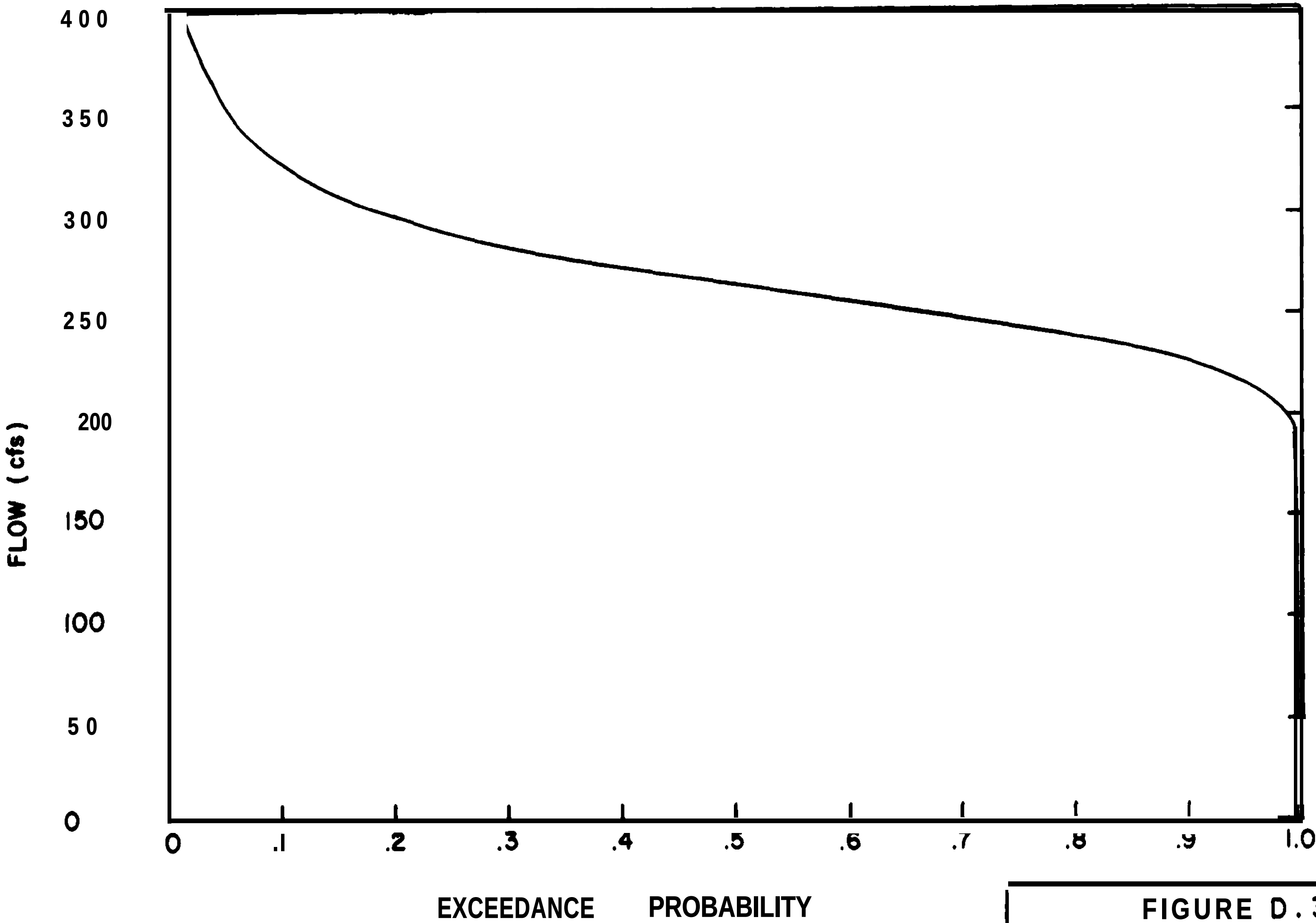


FIGURE D.3

LEMHI RIVER
HABITAT IMPROVEMENT STUDY

DAILY FLOW DURATION LEMHI RIVER AT USGS GAGE (MARCH)

DATE: NOVEMBER 1985

JOB NUMBER: S1028.03

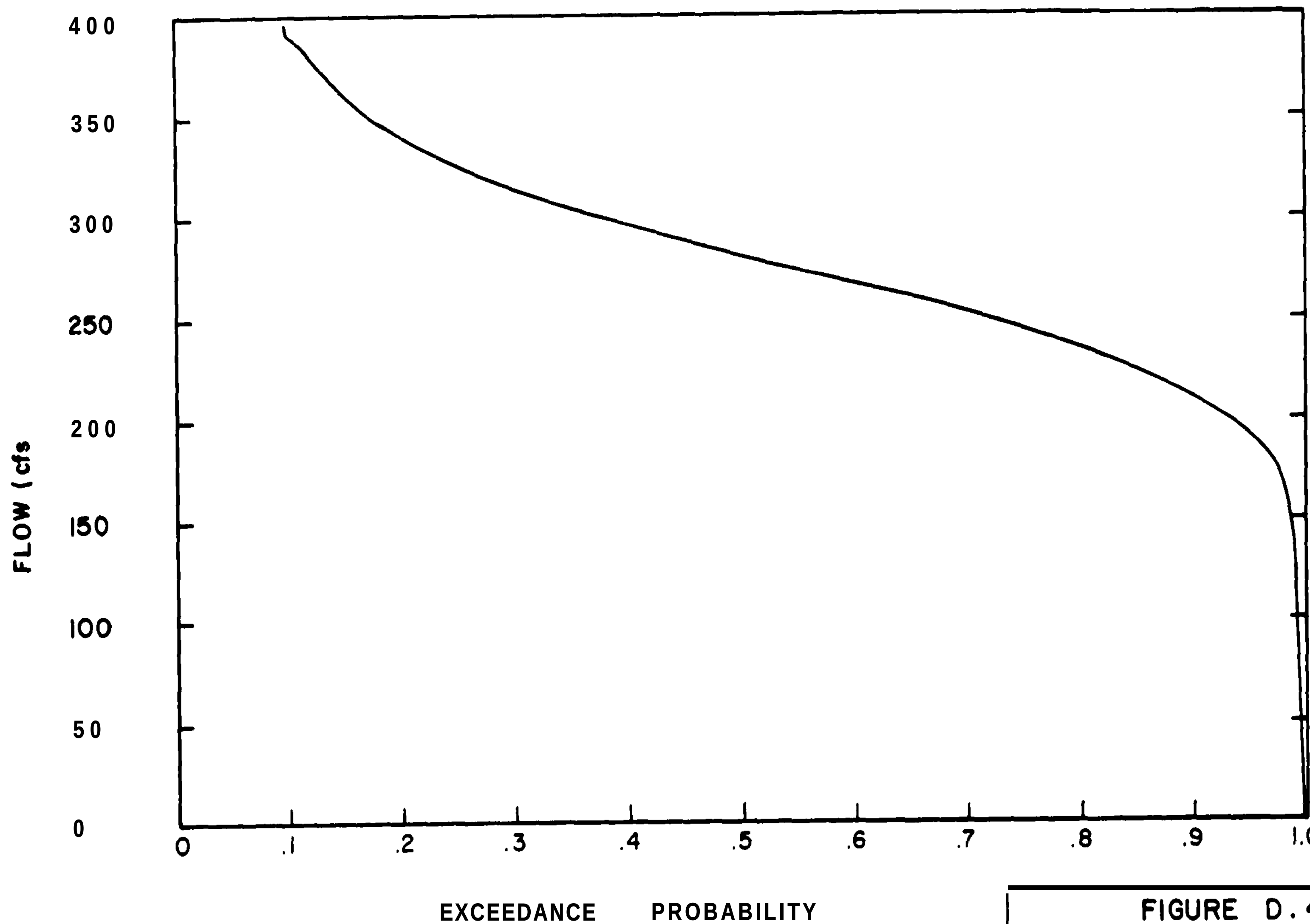


FIGURE D.4

LEMHI RIVER
HABITAT IMPROVEMENT STUDY

DAILY FLOW DURATION LEMHI RIVER AT USGS GAGE (APRIL)

DATE: NOVEMBER 1985

JOB NUMBER: S 1028.03

OTT

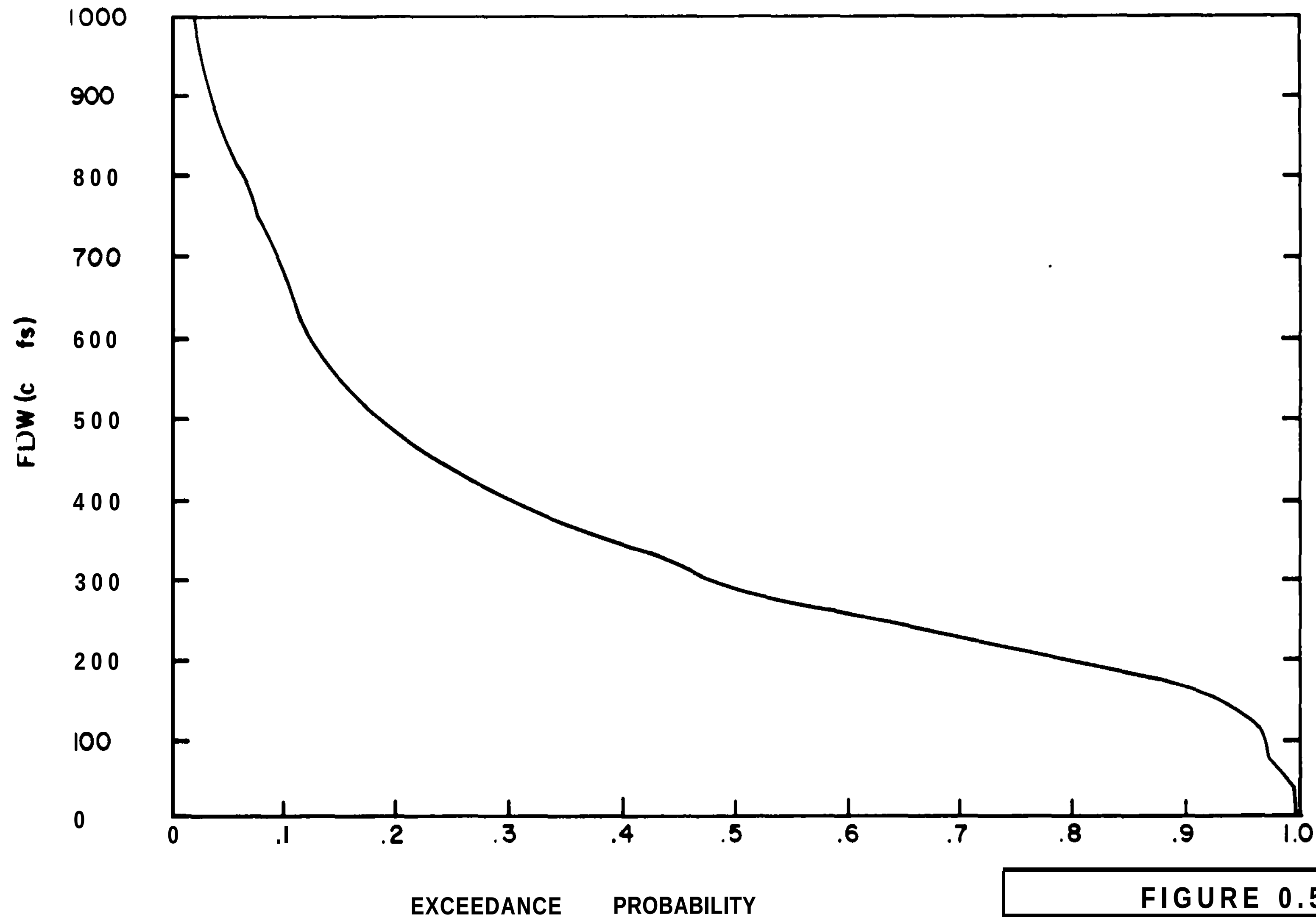


FIGURE 0.5

LEMHI RIVER
HABITAT IMPROVEMENT STUDY

DAILY FLOW DURATION LEMHI RIVER AT USGS GAGE (MAY)

DATE: NOVEMBER 1985
JOB NUMBER: S1028.03

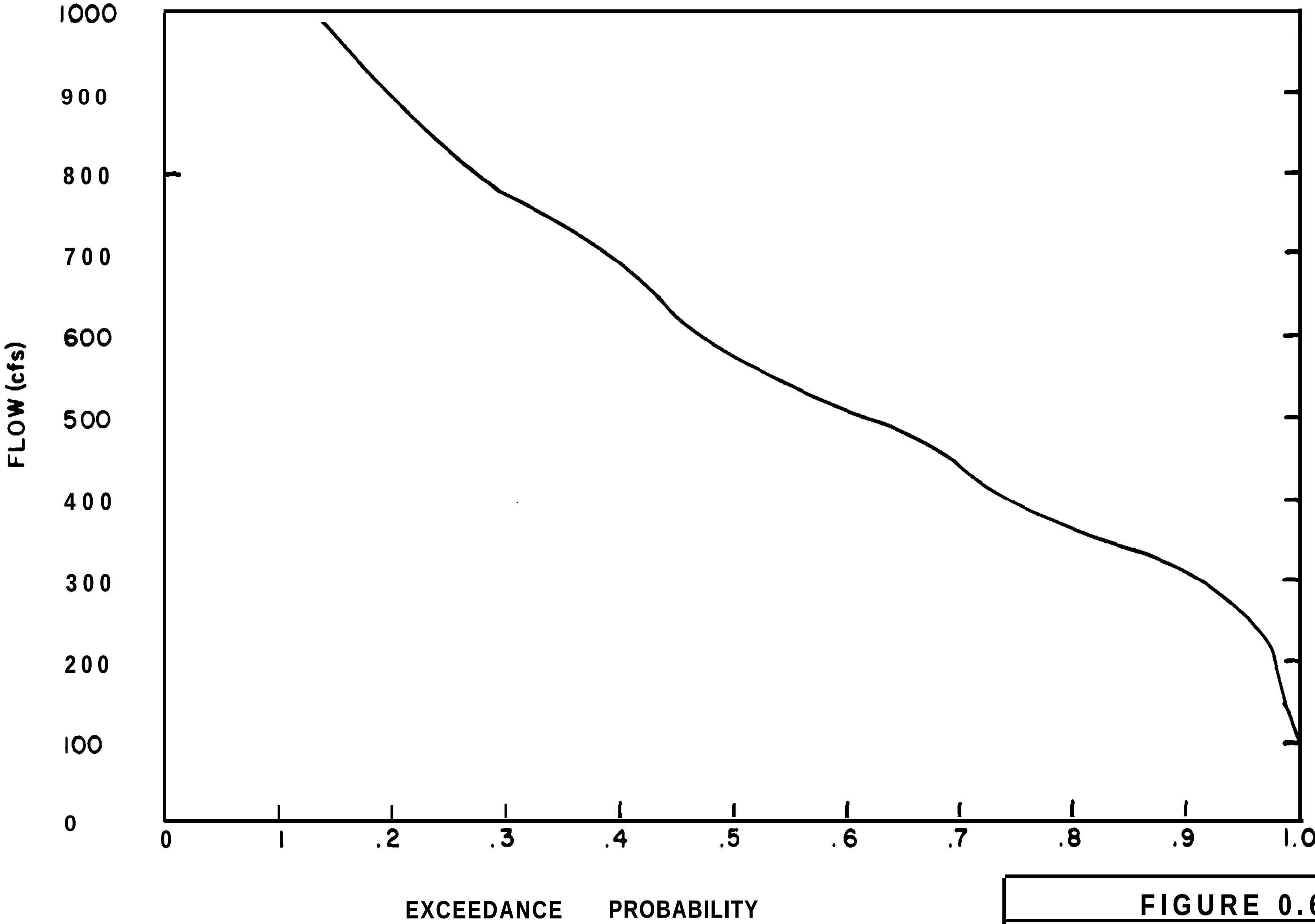


FIGURE 0.6

LEMHI RIVER
HABITAT IMPROVEMENT STUDY

DAILY FLOW DURATION LEMHI RIVER AT USGS GAGE (JUNE)

DATE: NOVEMBER 1985
JOB NUMBER: S1028.03

OTT

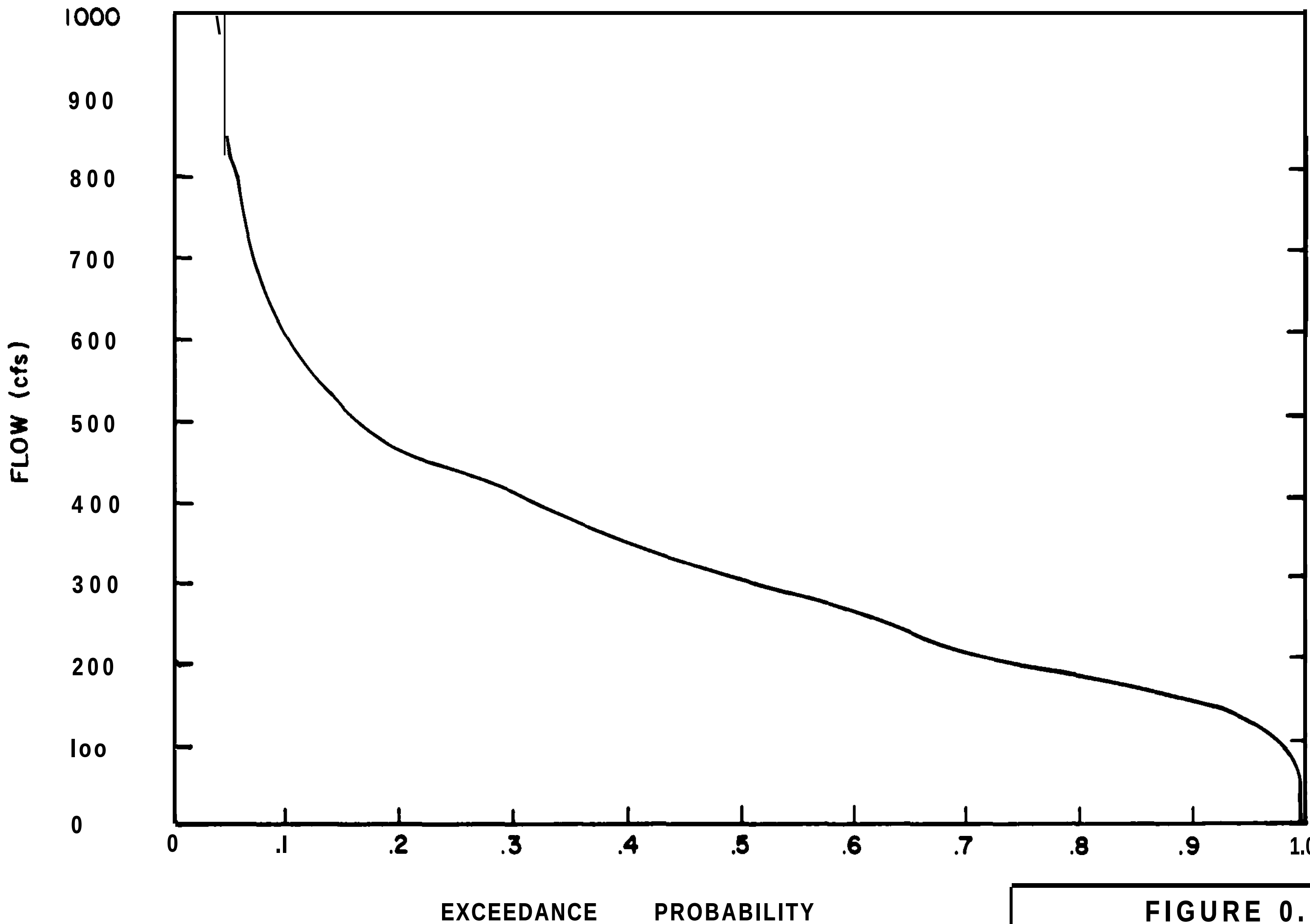


FIGURE 0.7

LEMH I RIVER
HABITAT IMPROVEMENT STUDY

DAILY FLOW DURATION LEMHI RIVER AT USGS GAGE (JULY)

DATE: NOVEMBER 1985

JOB NUMBER: S 1028.03

OTT

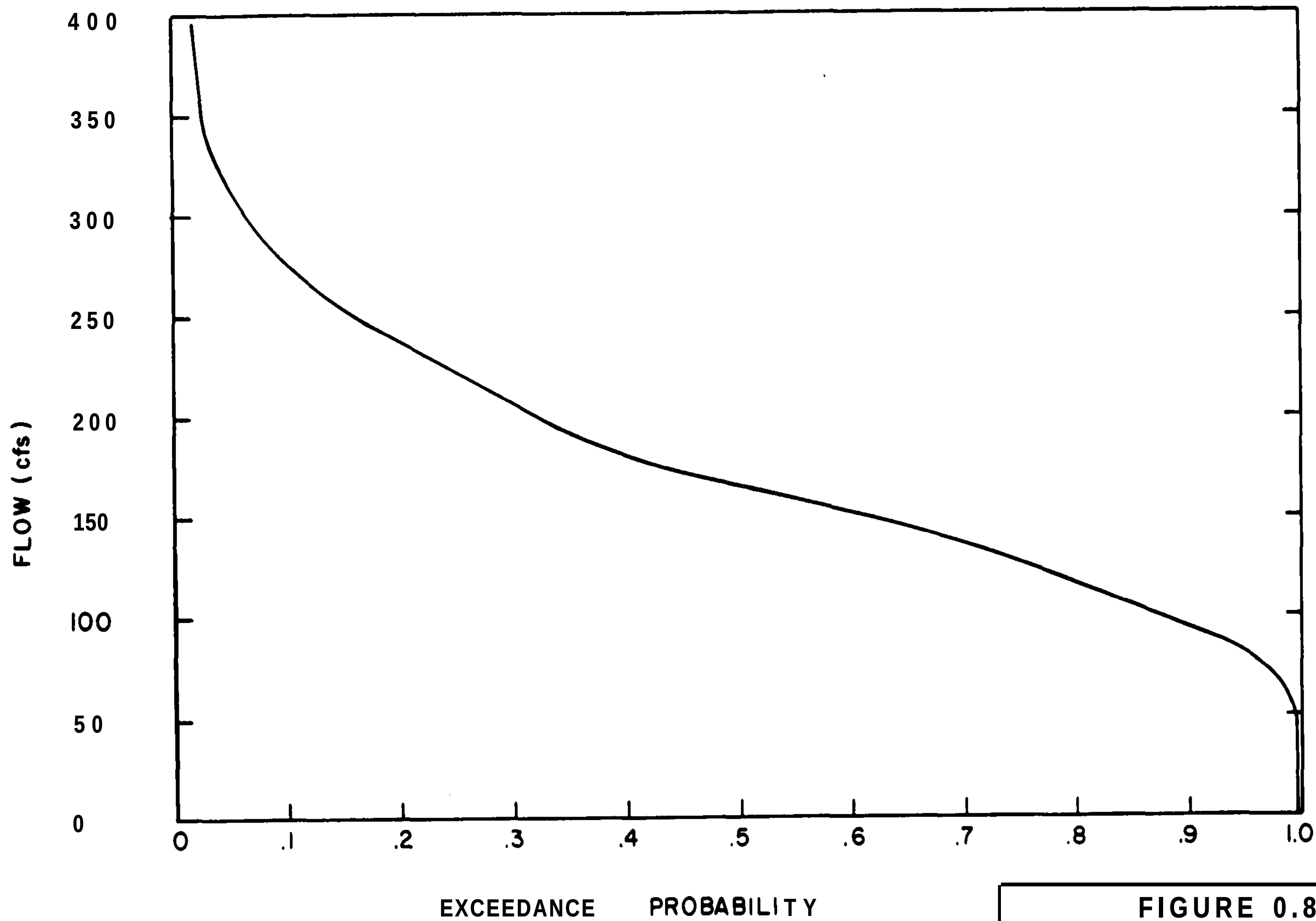


FIGURE 0.8

LEMHI RIVER
HABITAT IMPROVEMENT STUDY

DAILY FLOW DURATION LEMHI RIVER AT USGS GAGE (AUGUST)

DATE: NOVEMBER 1985

JOB NUMBER: S 1028.03

OTT

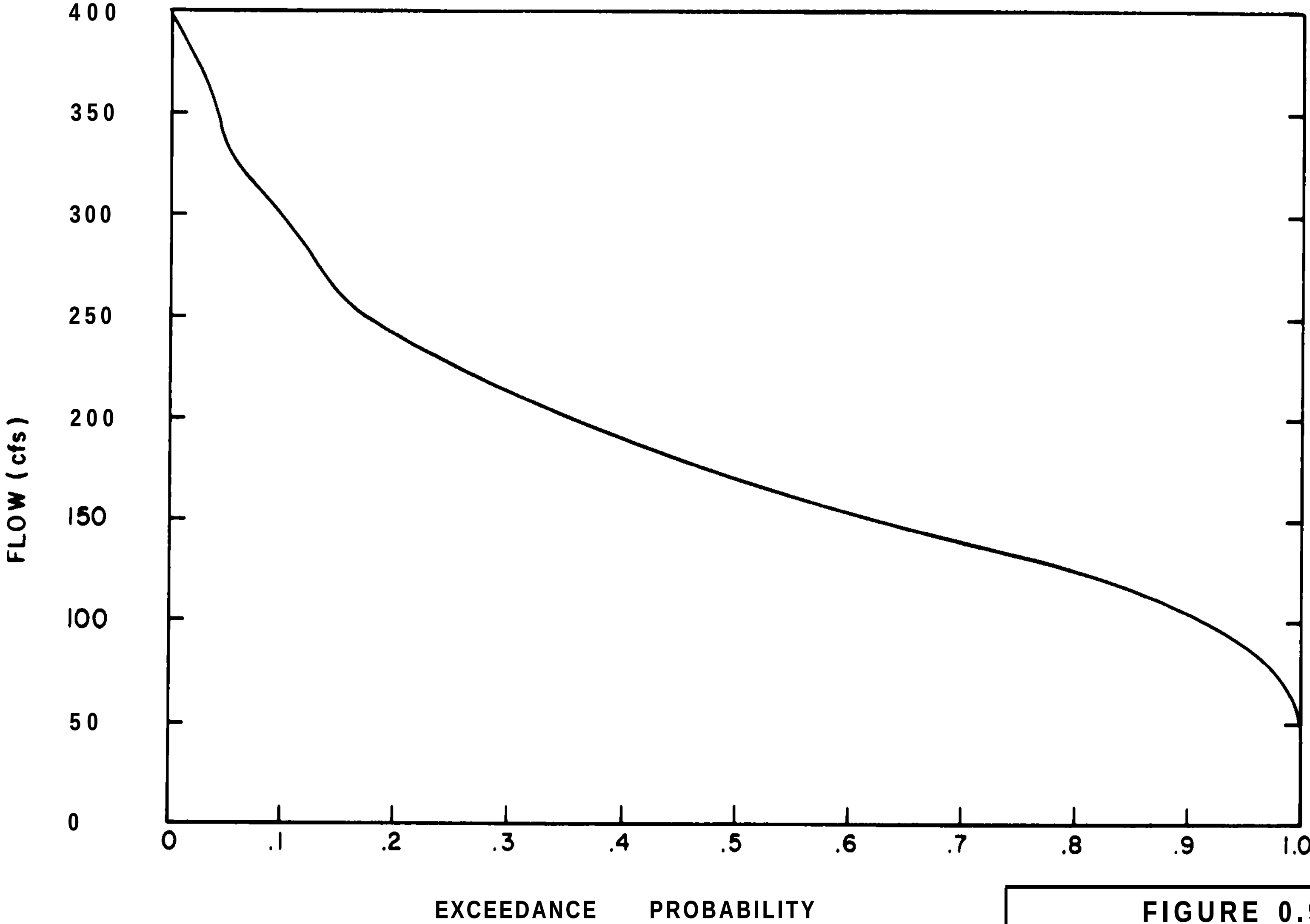


FIGURE 0.9

LEMHI RIVER
HABITAT IMPROVEMENT STUDY

DAILY FLOW DURATION LEMHI RIVER AT USGS GAGE (SEPTEMBER)

DATE: NOVEMBER 1985

JOB NUMBER: S 1028.03

OTT

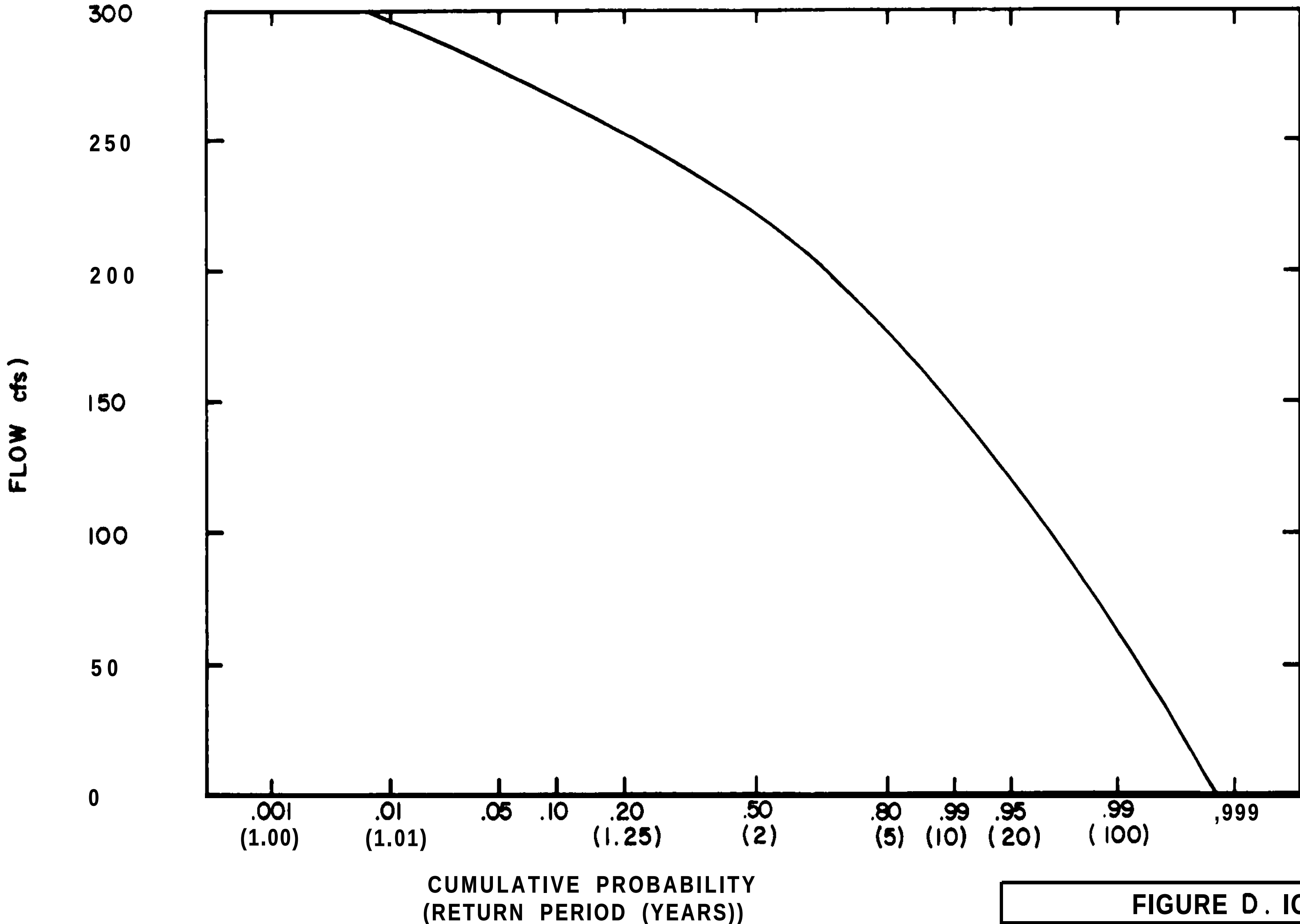


FIGURE D. 10

LEMH I RIVER
HABITAT IMPROVEMENT STUDY

SPRING 15-DAY LOW FLOWS AT USGS GAGE FOR LEMHI RIVER (1968-1984)

DATE: NOVEMBER 1985

JOB NUMBER: S 1028.03

OTT

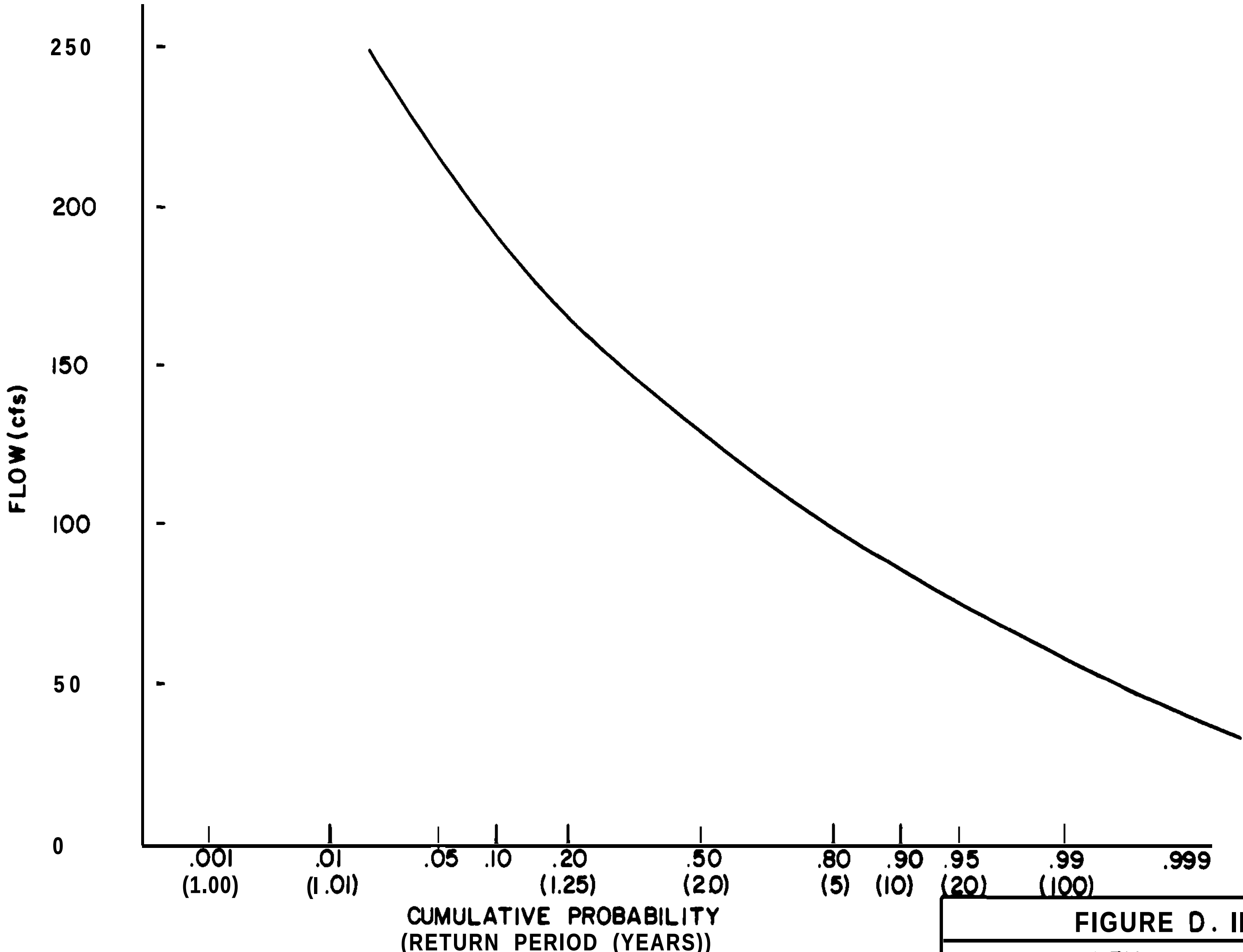


FIGURE D.11

LEMHI RIVER
HABITAT IMPROVEMENT STUDY

SUMMER 15-DAY LOW FLOWS AT USGS GAGE FOR LEMHI RIVER (1968-1984)

DATE: NOVEMBER 1985

JOB NUMBER: S 1028.03

OTT

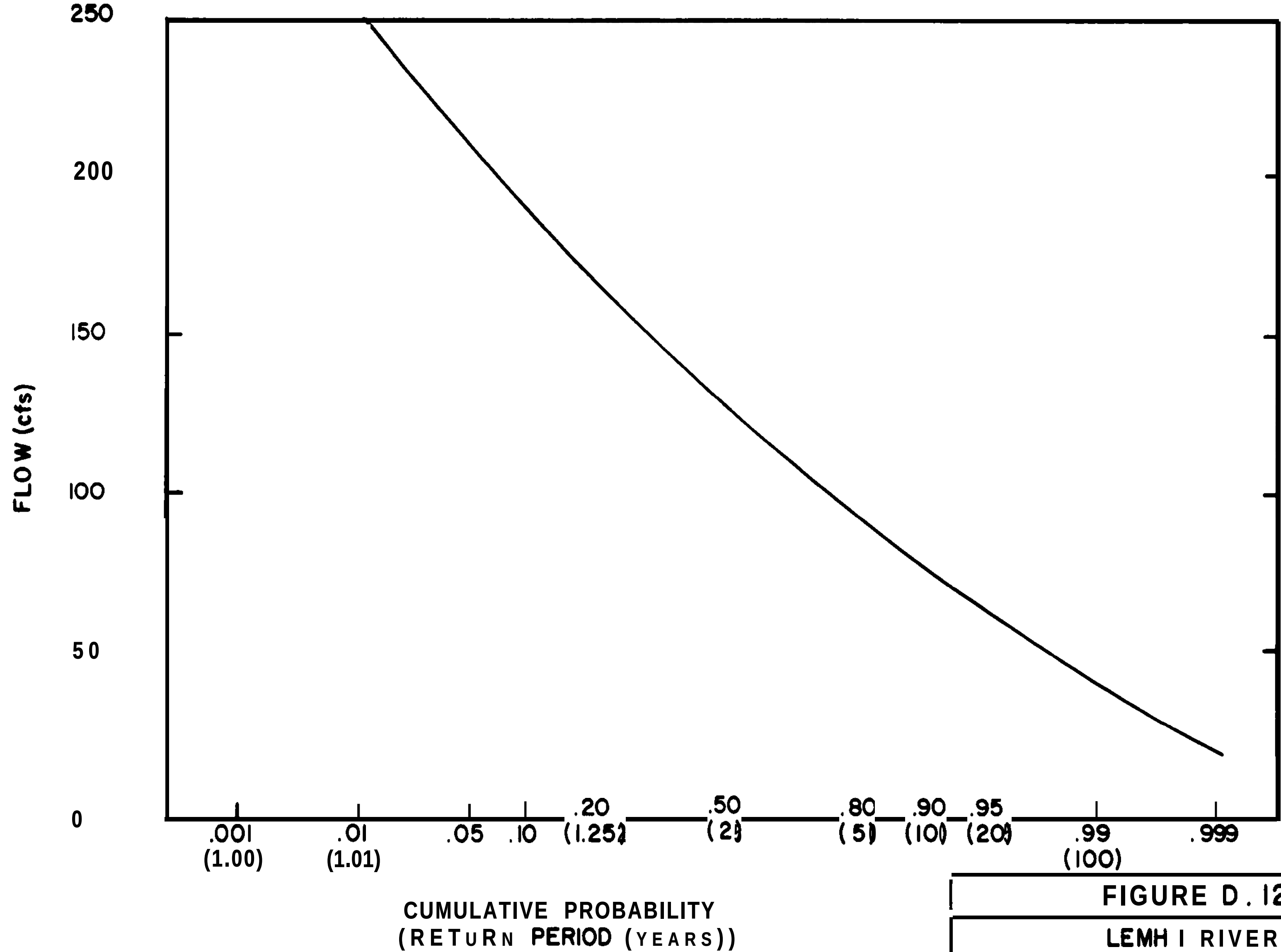


FIGURE D. 12

LEMHI RIVER
HABITAT IMPROVEMENT STUDY

SPRING 15- DAY LOW FLOWS
FOR HAYDEN CREEK (1968 - 1984)

DATE: NOVEMBER 1985

JOB NUMBER: S1028.03

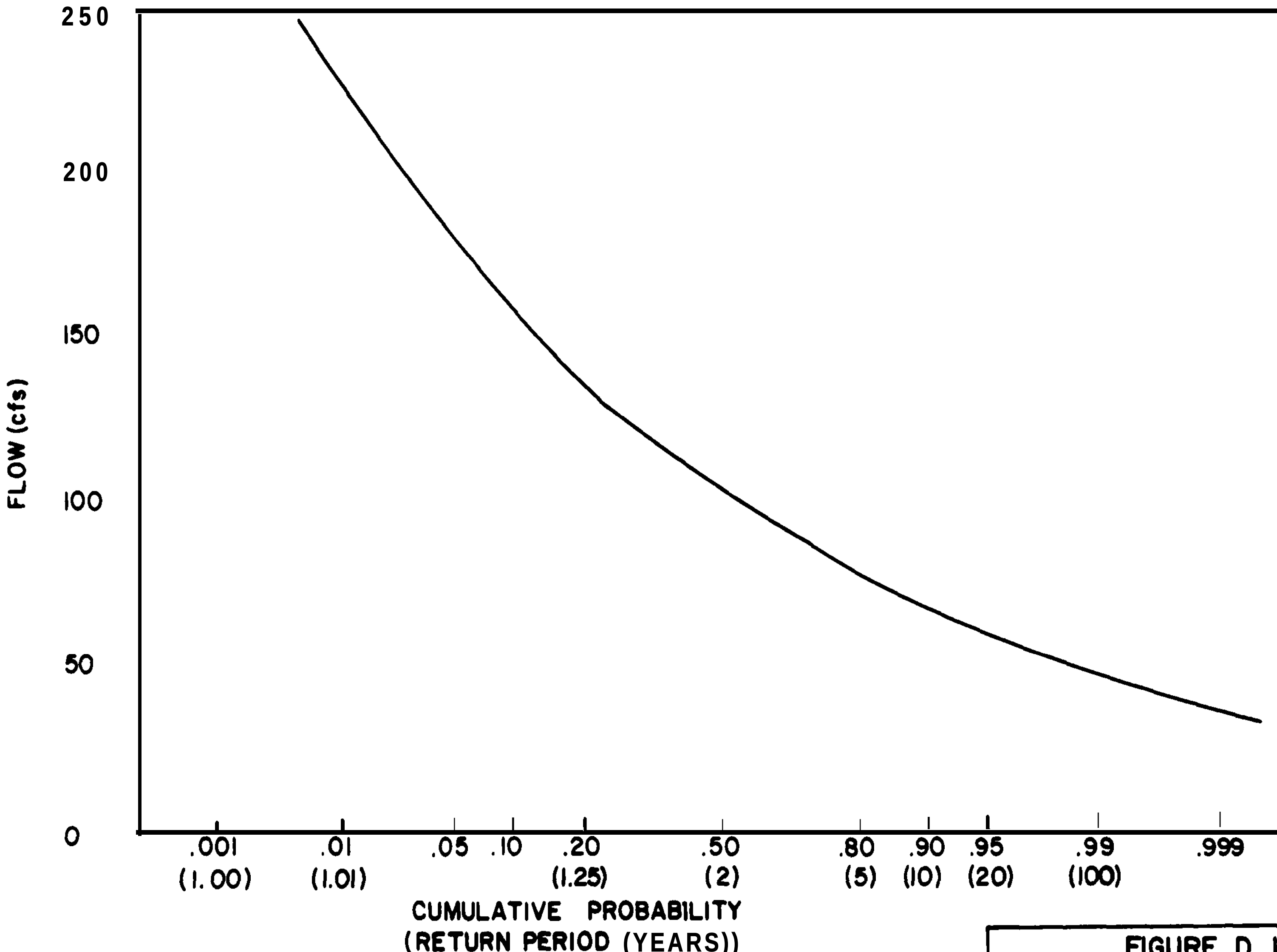


FIGURE D.13

LEMHI RIVER
HABITAT IMPROVEMENT STUDY

SUMMER 15-DAY LOW FLOWS
FOR HAYDEN CREEK (1968 - 1984)

DATE: NOVEMBER 1985

JOB NUMBER: S1028.03

OTT

APPENDIX E

UNIT COSTS

APPENDIX E

UNIT COSTS

All Unit Costs are based on the assumptions and conditions presented in the Cost Computation Parameters section of Chapter 3

CATEGORY/ITEM	UNITS	UNIT COST
EARTHWORK		
Trench Excavation	CY	$ 3.00
Native Trench Backfill	CY	1.00
Select Trench Backfill	CY	16.00
Common Excavation	CY	1.00
Common Fill	CY	1.00
Select Fill	CY	10.00
Engineered Fill	CY	6.00
Rock Excavation (General)	CY	25.00
Rock Excavation (Trench)	CY	35.00
Rip Rap (Material only)	CY	15.00
Rip Rap (Placement only)	CY	20.00
Hauling	CY	(2.00+.20/mile)
CONCRETE & BLOCK CONSTRUCTION		
Mass Concrete	CY	$ 150.00
Floors & Slabs on Grade	CY	150.00
Block Walls	SF	6.00
Nonstructural Reinforced Concrete	CY	250.00
Structural Reinforced Concrete	CY	350.00
PIPE		
Fabricated Steel Pipe		
150 PSI		
12"	LF	$ 16.20
18"	LF	23.40
24"	LF	30.60
30"	LF	54.00
36"	LF	64.80
42"	LF	75.60
48"	LF	104.20
Add 20% for orders under 400 ft.		
250 PSI		
12"	LF	$ 16.20
18"	LF	23.40
24"	LF	43.20
30"	LF	72.00
36"	LF	108.90
42"	LF	152.10
48"	LF	173.70
Add 20% for orders under 400 Ft.		

UNIT COSTS
(continued)

CATAGORY/ITEM	UNITS	UNIT COST
Pipe cont.		
Concrete		
12"	LF	$ 12.00
15"	LF	14.50
18"	LF	17.00
24"	LF	22.00
30"	LF	28.00
Add 20% for orders less than 200 Ft.		
Corrugated Metal		
12"	20 FT Section	$ 24.00
15"	20 FT Section	29.00
18"	20 FT Section	32.50
24"	20 FT Section	41.50
30"	20 FT Section	53.50
PVC		
12"	20 FT Section	$ 26.00
15"	20 FT Section	37.50
18"	20 FT Section	51.00
LAND		
Productive Farmland	AC	$1,500.00
Dry "Grazing"	AC	400.00
WELLS, PUMPS, AND IRRIGATION EQUIPMENT		
Drilling & Casing	$(l0+DIA(in)x2,5)xDepth(ft)	
Pumps		
Volume (for flood irrigation)	CFS	$1,300.00
Pressure(for sprinkler irrigation)	CFS	3,000.00
Wheel Line (complete)	l/4 MI	6,800.00
ELECTRIC RATES		
<3,000 kwh/month	kWh	$ .0438
>3,000 kwh/month	$2.86x(kW)+.0323253x(kWh)	
MOTORS		
2hp	EA	$ 200.00
5hp	EA	275.00
POWERLINE	MI	$45,000.00
FABRICATED STEEL	LB	$ 2.00

UNIT COSTS
(continued)

CATAGORY/ITEM	UNITS	UNIT COST
WOOD PRODUCTS		
Timber	Mbf	$ 350.00
3/8 Plywood (exterior)	4'x8' panel	15.00
5/8 Plywood (exterior)	4'x8' panel	18.00
GATES AND VALVES		
Low Head Canal Gates		$\$12(DIA(in))^{1.4}$
Valves		$\$ \; 11(DIA(in))^{2}$
FISHSCREENS		
Perforated Aluminum	SF	$ 20.00
Wedge Wire (stainless)	SF	75.00
Add 30% for quantities under 200 S.F.		

APPENDIX F

SUBREACH HABITAT DATA

TABLE F-l
(from Buell 1985a)

Surface areas (in square yards) of six habitat types in 19 specific subreaches of the Lemhi River, Idaho.

SUBREACH	DATE (1985)	POOL	RIFFLE	RUN	POCKETWATER	SIDECHANNEL	BACKWATER
0-L1	6/23	133.33	16857.67	11960	0	100	176.67
Ll-2	6/23	33.33	15843.33	5790	126.67	126.67	83.33
L2-2B	6/23	800	5083.33	4530	33.33	0	83.33
L2B-3	6/23	3838.33	21171.67	8958.33	0	1743.33	593.33
W-3B	6/23	7826.67	39363.33	15598.33	0	780	973.3
L3B-L3A	6/23	3988.33	3595.00	1881.67	0	0	90
WA-5	6/23	4598.17	19479.17	5000	235	370	268.33
L5-6	6/23	593 l 33	4023.33	1623.33	650	0	0
u-7	6/23	0	13916.67	9530	0	203.33	183.33
L7-7A	6/23	0	350	200	0	0	0
L7A-8	6/23	4.44	539.11	174.44	0	0	0
L8-8A	6/24	0	11250	4163.33	66.67	0	0
L8A-9	6/24	0	1506.67	366.67	116.67	0	183.33
L9-10	6/24	50	9870	8393.33	16.67	0	0
Ll0-11	6/24	0	10096.67	4860	0	583.33	133.33
Lll-12	6/24	0	3710	1783.33	0	0	0
L12-13	6/24	0	4366.67	2843.33	83.33	0	0
Ll3-14	6/23	400	6433.33	2226.67	0	0	0
L14-15	6/23	1233.33	11350	4850	0	400	33.33
Ll5-16	6/23	116.67	7216.67	4966.67	0	346.67	50
L16-17	6/24	670	3166.67	1100	0	0	0
Ll7-18	6/24	66.67	14283.33	2350	0	166.67	0
Ll8-19	6/24	133.33	14283.33	2550	0	123.22	20
Ll9-19A	6/24	250	20733.33	20083.33	0	0	0
L19A-20	6/24	0	2766.67	300	0	0	0
L20-21	6/24	66.67	6616.67	116.67	0	50	110
L21-22	6/24	1300	5078.33	2271.67	403.33	0	56.67
L22-22A	6/24	661.67	4435	1848.38	0	0	0
L22A-23	6/24	710	9868.33	4091.67	165	180	263.33
L23-24	6/24	4338.67	26630	7160	388.33	1345.67	888.67
L24-25	6/24	315	1320	485	0	0	0
L25-26	6/24	0	5098.33	1126.67	0	0	0
L26-27	6/25	1173.33	25233	4036.67	160	156.67	80
L27-28	6/25	14441.67	7040	2369.33	445	194	0
L28-29	6/25	517.58	6945	1572.67	250	0	0
L29-30	6/25	3140	18591.67	6205	50	660	323.33
L30-30A	6/25	2211.67	17833	4837	0	43.33	400.67
WOA-31	6/25	260	7675	573.83	156.67	0	0
WI-31B	6/25	33.33	10583.33	133.33	0	33.33	0
L31B-31A	6/25	376.67	2142.67	2960	0	103.33	0
L31A-32	6/25	0	7166.67	293.33	0	0	30
L32-33	6/25	0	1400	600	0	0	0
L33-34	6/25	133.33	4683.33	333.33	0	0	0

TABLE F-l (continued)

Surface areas (in square yards) of six habitat types in 19 specific subreaches of the Lemhi River, Idaho.

SUBREACH	DATE (1985)	POOL	RIFFLE	RUN	POCKETWATER	SIDECHANNEL	BACKWATER
L34-35	6/25	0	8466.67	700	0	0	100
L35-35A	6/25	133.33	2433.33	200	0	0	0
L35A-36	6/25	0	17503.33	433.33	0	0	43.33
L36-38	6/25	0	0	0	0	0	0
L38-39	6/25	0	17283.33	4350	0	0	0
L39-40	6/25	67.67	11566.67	1100	0	0	0
L40-41	6/25	0	950	683.33	0	0	0
L41-42	6/25	0	2150	1416.67	0	0	0
L42-43	6/25	3412.5	12150	11200	0	0	0
L43-43A	6/25	850	775	3875	0	0	0
L43A-43B	6/25	2512.5	5437.5	8187.5	500	0	0
L43B-43C	6/25	1612.5	850	1462.5	0	0	0
LAX-44	6/25	4912.5	10387.5	14287.5	0	0	0
IA4-45	6/25	0	0	0	0	0	0
L45-45A	6/25	5125	20987.5	18475	0	2812.5	600
L45A-45B	6/26	1287.5	9637.5	4900	0	0	0
L45B-45C	6/26	1675	1512.5	8787.5	0	0	0
L45C-45D	6/26	0	0	600	0	0	0
L45D-46	6/26	605	13087.5	9275	0	1312.5	0
L46-46A	6/26	912.5	1637.5	3575	0	0	0
L46A-47	6/26	2975	15520	13712.5	0	0	0
L47-48	6/26	350	1375	4125	0	0	0
U8-49	6/26	200	837.5	1162.5	0	0	0
L49-50	6/26	0	41190	3000	0	26.67	216.67
L50-51	6/26	0	5466.67	0	0	0	0
L51-51A	6/26	0	7567.67	1600	0	0	33.33
L51A-52	6/26	150	10233.33	2783.33	0	50	100
L52-54	6/26	0	5936 .67	550	0	0	0
L54-57	6/26	1583.33	27980	10333.33	0	150	0
L57-58	6/26	200	0	0	0	0	0
L58-58A	6/26	0	2203.33	2333.33	0	90	0
L58A-58B	6/26	0	1933.33	850	0	66.67	0
L58B058C	6/26	0	4950	2266.67	0	33.33	166.67
L58C-59	6/26	266.67	7283.33	4666.67	0	0	0
L59-60	6/26	5243.98	6355	5095.67	130	223.33	1173
L60-61	6/26	2730	2255	2901.67	16.67	0	36.67
Lbl-62	6/26	15532.5	18170	21178.33	75	1600.5	1276.67
L26-63	6/27	7735	12582	10495	0	1373.16	226.67

TABLE F-2
(from Buell 1985a)

Surface areas (in square yards) of six habitat types and total fish habitat in five study reaches of the Lemhi River, Idaho.

REACH	POOL	%	RIFFLE	%	RUN	%	POCKETWATER	%	SIDECHANNEL	%	BACKWATER	%	TOTAL
01	20965.93	(7.4)	172945.95	(60.7)	83029.43	(29.2)	1245.01	(0.4)	3906.66	(1.4)	2678.31	(0.9)	284771.29
02	29534.59	(9.3)	205166.33	(64.8)	74337.06	(23.5)	1944.99	(0.6)	3622.90	(1.1)	1825.33	(0.6)	316431.20
03	3215.00	(2.5)	109687.33	(83.7)	17187.48	(13.1)	156.67	(0.1)	179.99	(0.1)	574.00	(0.4)	131000.47
04	30008.33	(8.4)	196922.67	(54.9)	125741.66	(35.1)	500 .00	(0.1)	444 1.67	(1.2)	950.00	(.03)	358564.33
05	31508.15	(22.5)	53528.66	(38.3)	47454.01	(33.9)	221.67	(0.2)	4296.99	(3.1)	2879.68	(2.1)	139889.16

TABLE F-3

(from Buell 1985a)

Surface areas (in square yards) of six habitat types in 14 specific reaches of Hayden Creek, Idaho below the upper bridge crossing.

SUBREACH	DATE (1985)	POOL	RIFFLE	RUN	POCKETWATER	SIDECHANNEL	BACKWATER
0 H1	6/27	0	2833.33	116.67	0	0	0
Hl-H2	6/27	0	733.33	116.67	0	0	0
H2-H3	6/27	0	19233.33	1200	0	0	50
H3-H4	6/27	0	120	100	0	0	0
H4-H5	6/27	0	14850	216.67	0	0	0
H5-H6	6/27	0	483.33	0	0	0	0
H6-H7	6/27	0	4466.67	0	0	0	0
H7-BCr	6/27	66.67	11150	183.33	0	0	66.67
BC4-H9	6/27	2775	500	825	24300	538.5	0
H9-H10	6/27	1900	2787.5	2625	32300	225	0
Hl0-Hll	6/28	2475	8850	2100	25337.5	350	100
Hll-H12	6/28	1600	5275	1837.5	20712.5	0	0
H12-BVCr	6/28	225	337.5	725	2627.5	0	0
BVCr-Bridge	7/01	150	20946.67	313.33	860	0	0
Below BVCr							
Surface area	6/28	9841.67	71619.99	10045.84	106287.50	1112.5	216.67
percentage	6/28	(4.5)	(36.1)	(5.1)	(53.6)	(0.5)	(0.1)

BCr = Basin Creek
BCVr = Bear Valley Creek
Bridge= upper bridge crossing

TABLE P-4

(from Buell 1985a)

Surface areas (in square yards) of six habitat types in six specific reaches Big Springs Creek, Idaho.

SUBREACH	DATE (1985)	POOL	RIFFLE	RUN	POCKETWATER	SIDECHANNEL	BACKWATER
0-BSC2	7/17	100	6090	2393.33	0	10	0
BSC2-BSC3	7/17	260	7416.67	3403.33	0	13.33	83.33
BSC3-BSC4	7/17	0	850	216.67	0	6.67	50
BSC4-BSC5A	7/17	66.67	1933.33	683.33		20	73.33
BSC5A-BSC5	7/17	0	483.33	166.67	0	0	0
BSC5-BSC6	7/17	70	7023.33	3356.67	0	466.67	83.33
TOTAL							
Surface Area	7/17	496.67	23796.66	10220.00	0	516.67	289.99
Percentage	7/17	(1.4)	(67.4)	(28.9)	(0.0)	(1.5)	(0.8)